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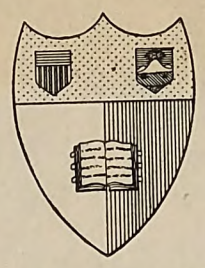

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RÉSULTATS DES EXPLORATIONS
ZOOLOGIQUES, BOTANIQUES, OCÉANOGRAPHIQUES ET GÉOLOGIQUES
ENTREPRISES AUX
INDES NÉERLANDAISES ORIENTALES en 1899—1900,
à bord du SIBOGA
SOUS LE COMMANDEMENT DE
G. F. TYDEMAN
PUBLIÉS PAR
MAX WEBER
Chef de l'expédition.

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LXV. Deposita marina, O. B. Böggild.
LXVI. Résultats géologiques, A. Wichmann.

Siboga-Expeditie

THE PENNATULACEA OF THE SIBOGA EXPEDITION

WITH A GENERAL SURVEY OF THE ORDER

BY

SYDNEY J. HICKSON M. A. (Cantab.) D. Sc. (Lond.)
Dr. Bot. et Zool. (Groningen) F. R. S.
Professor of Zoology in the Victoria University of Manchester.

With 10 plates, 45 text figures and 1 chart

Monographe XIV of:

UITKOMSTEN OP ZOOLOGISCH, BOTANISCH, OCEANOGRAPHISCH EN GEOLOGISCH GEBIED

verzameld in Nederlandsch Oost-Indië 1899—1900

aan boord H. M. Siboga onder commando van
Luitenant ter zee 1e kl. G. F. TYDEMAN

UITGEGEVEN DOOR

Dr. MAX WEBER
Prof. in Amsterdam, Leider der Expeditie

(met medewerking van de Maatschappij ter bevordering van het Natuurkundig Onderzoek der Nederlandsche Koloniën)

BOEKHANDEL EN DRUKKERIJ
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XIV

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INTRODUCTION.

When I accepted the invitation that was sent to me ten years ago to write a description of the Pennatulacea collected by the Siboga expedition I expected to receive only a small collection and anticipated a task that could be completed in a few months.

The U. S. Exploring Expedition in 1838—1842, the Challenger Expedition in 1873—1876, and many independent naturalists had made collections of the marine zoology of the Archipelago but the only sea pens that were known to exist in that area were a few species of *Pteroeides*, two or three species of *Virgularia* and one species of each of the genera *Pennatula*, *Cavernularia*, *Veretillum* (?) and *Stachyptilum*. I did not expect, therefore, what I found when I made a preliminary examination of the material on its arrival, that I had to deal with the richest collection of specimens of sea-pens that has ever been made by a single scientific expedition.

Owing to the pressure of other work, that was in progress at the time, there was some delay in beginning the detailed examination of the species but, when I was able to devote nearly the whole of my spare time to the research, I found that it would take me several years to complete a memoir of such a large and varied collection. The splendid preservation of the specimens and the rarity of many of the genera tempted me to investigate certain anatomical details and almost every species opened up questions of morphological interest which, although assisting systematic study, delayed the completion of my work.

The large number of specimens representing a considerable majority of the known genera of the world presented a unique opportunity for a complete survey of the Order Pennatulacea as a whole and a revision of its classification and I included, therefore, in my studies the examination of several genera and species that are not in the Siboga collection.

The great monograph on Pennatulacea published by KÜKENTHAL and BROCH in 1911 anticipated, to some extent, my full purpose and has relieved me of the necessity of writing a review of the history and literature of the group; but as I have found myself in disagreement with many of the views expressed in the "Valdivia" monograph I have ventured to carry out the work very much on the lines proposed.

Although my standpoint is essentially different from that of the Breslau school of zoologists as regards the conception of genera and species I trust that the controversial section of this memoir will not obscure my appreciation of their magnificent work. Whatever views may prevail

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in the future, the "Valdivia" monograph, as a record and detailed description of species, must remain as an essential work of reference for students of the Order of Sea-pens.

It may be a disappointment to some of my colleagues that in the description of this large collection I have not found it necessary to propose a single new generic name; in fact, if my views are accepted the result will be a reduction rather than an increase in the number of genera.

But it is just on this point that controversy turns. In the early days of the study of the Pennatulacea, when specimens came to hand at long intervals and in various conditions of imperfect preservation, it was impossible to make a complete investigation of the variability of any one species and consequently new generic names, with some justification, were freely proposed; but, with increasing knowledge, many of these genera have been linked together by intermediate forms and the number of recognised genera has been reduced. The profound and detailed study of Pennatulid morphology by KÖLLIKER (1872) made the first important step towards a scientific classification of the Order. It is true that in his memoir he added nine new genera to the list and that most of them have stood the test of time; but his work led to the final abandonment of at least eight unsound generic names that burdened the literature of those early days. Since that date the important researches of JUNGERSEN (1904) on the Pennatulacea of the North Atlantic Ocean have rendered good service in still further reducing the number of generic names and subsequent authors have also assisted to some extent in our progress in the same direction.

Notwithstanding this general tendency several new genera have recently been proposed on what appear to me insufficient knowledge or unreliable characters and I have given reasons in this memoir why several of these should not be recognised.

The determination whether a particular species should or should not be the type of a distinct genus cannot be subject to any definite rules. It is and must remain a matter of individual opinion where the line should be drawn between genus and species. Nor can it be laid down in a group such as the Pennatulacea that certain characters are useful throughout for the separation of genera and species and that others are of little or no value for the purpose. Experience alone can determine the value of these characters in each individual case.

In deciding whether a given species should be separated as a distinct genus I have endeavoured to find at least two constant characters by which it differs from other species closely related to it and to reject it as generic type if I failed. But even this general principle is not one which can be rigidly applied. In some cases a single character of a very pronounced kind may be sufficient for generic diagnosis. For example the genus *Umbellula* is sharply distinguished from its neighbours by the single character of having the autozooids arranged in a single tuft or tassel at the distal end of the rachis. Again the genus *Scytalium* is distinguished from the genera that come closest to it by the shape and size of the spicules. In the case of both of these genera, however, there are no species known that can be regarded as intermediate, as regards the single character, between the genus and its neighbours and there is no second character that shows the same distinction.

In some cases moreover it may be desirable either for historical continuity or to emphasise

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some one feature of special morphological interest to retain an old generic name. For example it seems to me desirable to retain for the present both the generic names Lituaria and Veretillum notwithstanding the fact that the only character that separates them is that very variable one in this family — the shape of the spicules —; because the thick double-star or capstan spicule of Lituaria is of special interest in the discussion of the theory of the evolution of the Pennatulacea.

But if no exact and scientific definition of what is meant by a genus can be formulated there can be no doubt that as a matter of convenience it is better to retain a few rather than a large number of generic names.

My conception of the order is that it consists of only a few well-marked generic groups and that new generic names should not be introduced without some very strong reason. In the collection made by the Siboga, rich and varied as it is, all the specimens, with one exception, appear to fit into one or another of the older generic groups although in some cases they necessitate some slight alteration of or addition to the generic diagnosis. The one exceptional case is that of *Sclerobelemnon magniflorum* for which, at first I was inclined to suggest a new generic name. The species was represented by only two specimens, however, and I am unable to determine its range of variability. Many of the details of its structure resemble those of Sclerobelemnon but it is found in water that is much deeper (472 metres) than that in which the other species of the genus are found (20—80 metres). After some hesitation, therefore I have decided to regard it as a deep-sea species of the genus Sclerobelemnon to which it is undoubtedly most closely related.

But although I have not added a new genus to the list it has been necessary to propose no less than nineteen new species. Some of these I believe, will stand the test of time; others may have to submit to amalgamation when further specimens from intermediate localities and depths have been studied.

The richness of the Siboga collection may be indicated by the statement that it consists of about 500 specimens, apart from numerous fragments too imperfect to be satisfactorily determined. These specimens I have arranged in 17 genera and 45 species. The "Challenger" collection consisted of 76 specimens together with an undefined number of specimens of the species *Leptoptilum gracile* (Funiculina quadrangularis Juv.?) and *Renilla Müllери*. These were arranged by KÖLLIKER in 20 genera and 38 species. The German "Valdivia" expedition obtained 200 specimens together with 188 specimens of *Funiculina* and these were arranged by KÜKENTHAL and BROCH in 13 genera and 38 species. In comparing the Pennatulid booty of the three expeditions it must be remembered, however, that by the system used in this memoir a far more conservative estimate is made of the value of generic and specific characters than in that adopted by previous authors.

Specimens of Pennatulacea were obtained by the "Siboga" expedition from 65 of the total number of 322 stations; a very remarkable record. The greatest depth at which any specimen was found was 1886 metres, the species being *Protoptilum celebense*.

The specimens were well distributed all over the area surveyed by the Siboga Expedition as can be seen by reference to the Map at the end of this volume. Specimens of the larger genera such as *Pteroeides*, *Virgularia*, *Scytalium* and *Sclerobelemnon* as well as the four species

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of *Umbellula* were found in widely separated localities, suggesting that they occur everywhere within the area at suitable depths and under favorable conditions of the sea-bottom. Nevertheless, attention may be called to the stations around Amboyna, the Banda Islands, the Kei Islands and the S. coast of Timor and Flores which yielded a particularly rich harvest of sea-pens.

The anatomical and histological researches that were made are described in the systematic part of the work. The special points to which attention may be directed are the researches on (1) the structure and distribution of the radial canals of *Virgularia* (p. 150), *Anthoptilum* (p. 145) and *Osteocella* (p. 147); (2) on the structure of the mesozooids of *Pennatula Murrayi* (p. 194) and (3) on the structure and relations of the remarkable brown tubes of *Pennatula Murrayi* (p. 197). I have examined the gonads of a large number of species of the Order and the general results arrived at are (1) that all the species are dioecious (2) that all the species are oviparous and (3) that the sexual organs may reach maturity long before the full size of the colony is attained.

With reference to the first two points I may say that I have not found a single instance of a hermaphrodite colony and no evidence whatever in support of a theory of protandry or protogyny, nor have I found a single case of an egg that has begun to segment within the body cavity of the parent.

In conclusion I have to acknowledge my thanks to many of my friends who have rendered assistance in preparing this memoir. To Mr. J. T. Wadsworth for much technical help in identifying species and measuring specimens, to Miss Emily R. Dust, for her skill and care in making the drawings and diagrams, to Miss Nora C. Rogers for much clerical and other assistance and to several of my former pupils for making counts and measurements, I am under great obligations. To Professor Max Weber, the Director of the Expedition, I am greatly indebted for his cordial cooperation in publishing this memoir according to my wishes and to him as well as to many friends in the Museums at Amsterdam and Leiden and in the British Museum I owe my thanks for facilities in the study of type specimens in the National collections.

I am also indebted to the Council of the Manchester Literary and Philosophical Society for permission to reproduce in this memoir text figures 30 & 31 on page 147.

Manchester, December 1915.

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The Order PENNATULACEA.

The Order Pennatulacea has been divided by previous authors into a number of Sections each of which contains one or more of the recognised families. The advantage of any such system of sectional grouping of the families is not very clear and as the systems that have been proposed differ from one another very materially they do not seem to represent a well-defined natural classification. On the other hand the disadvantages of the system of Sections are that it adds to the nomenclature, already overburdened, a number of names which are really of very little practical use and affords additional opportunities to the systematist, who is not an expert in the group, to go wrong in the identification of genera.

To give an example to illustrate my meaning: — The genus *Anthoptilum* is placed by KÖLLIKER (1880) in his section "Spicatae" the definition of which is "Rachis without pinnules, polyps sessile", by KÜKENTHAL and BROCH (1911) it is placed in their section "Pennatulacea bilateralia" the definition of which is "mit bilateral aber nicht wirtelförmig, an den Seiten des langgestreckten Kieles angeordneten Polypen".

A naturalist who obtained a specimen of KÖLLIKER's species *Anthoptilum Murrayi* would at once place it correctly in its right section; but if he obtained a specimen of *A. grandiflorum* from the Cape of Good Hope and finding that the autozooids are arranged in rows united at their bases to form primitive leaves he would place it in KÖLLIKER's section "Pennatuleae" or in the section "Pennatulacea penniformia" of KÜKENTHAL and BROCH and be led into error.

It is not necessary to give other examples nor to quote instances from the literature in which the sectional system has already led naturalists astray but apart from these considerations I would urge that these names be abandoned simply on the ground of simplicity in nomenclature.

The arrangement of the genera into families might, it is true be subjected to a very similar criticism and in some cases, as when the family is represented by only one genus, the family name is really superfluous.

Nevertheless, the study of both external form and internal anatomy as it progresses seems to emphasise the affinities of certain genera and to lead to the conclusion that the family groups are to a certain extent natural groups. For practical purposes, moreover, the family names are of some value as it is frequently necessary to refer in a systematic work to groups of allied genera and the use of the family name in such cases leads to brevity. But it must

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be insisted upon that in the Order Pennatulacea some of the families come into touch with one another and in others they seem to overlap as regards important characters. The Renillidae, the Umbellulidae and the Funiculinidae, all of them single genus families, are quite discontinuous, there are no species know to us that connect them with one another or with the other families of Pennatulacea. The Veretillidae through *Veretillum cynomorium* come into touch with *Sclerobelemnon Burgeri* belonging to the Kophobelemnonidae, and through *Actinoptilum molle* with *Echinoptilum* belonging to the Echinoptilidae. Similarly the Pennatulidae through *Leioptilum sinuosum* come close to *Sarcophyllum grande* belonging to the Pteroeididae and in some respects through *Acanthoptilum* with *Stylatula* belonging to the Virgulariidae.

This overlapping or close contact of some of the families of the Order makes it extremely difficult to draw up a scheme or key plan of the families that is absolutely reliable. Any such scheme must be subject to certain exceptions and may be of little value in dealing with young colonies but for the sake of those who have to identify specimens an attempt should be made to draw up a scheme that provides a minimum number of misleading statements and may be used as a preliminary guide to identification.

Scheme of the families: —

A. With a radially symmetrical rachis. Axis present, rudimentary or absent. VERETILLIDAE.

B. With a bilaterally symmetrical rachis.

I. With no axis.

1. With a cylindrical or club-shaped rachis . . . . . ECHINOPTILIDAE.
2. With a flattened leaf-shaped rachis . . . . . RENILLIDAE.

II. With an axis.

1. Autozooids irregularly distributed or arranged in longitudinal rows on the rachis.
   a. Autozooids without calices . . . . . KOPHOBELEMNONIDAE.
   b. Autozooids with calices.
      a*.[1]) Autozooids of various stages of growth arranged in closely set oblique rows on the rachis . FUNICULINIDAE.
      b*. Autozooids arranged in longitudinal rows on the rachis . . . . . PROTOPTILIDAE.
2. Autozooids arranged in whorls or bilateral pairs.
   a. Autozooids arranged in several whorls or pairs . . CHUNELLIDAE.
   b. Autozooids arranged in a single terminal whorl or tassle. UMBELLULIDAE.
3. Autozooids arranged in transverse or oblique rows or in primitive leaves.
   a. With[2]) ventral radial canals. Gonads developed in the fully formed autozooids . . . . . PAVONARIIDAE.
   b. With dorsal radial canals. Gonads developed in the fully formed autozooids. . . . . ANTHOPTILIDAE.

1) See BROCH 1913(2) p. 11.
2) See p. 136.

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c. With dorsal radial canals. Gonads developed in the young autozooids. . . . . VIRGULARIIDAE.

4. Autozooids arranged in well developed leaves supported by spicules.

a. With no siphonozooids on the leaves . . . . . PENNATULIDAE.

b. With siphonozooids on the leaves. . . . . PTEROEIDIDAE.

The genera Stachyptilum and Stephanoptilum occupy a very doubtful position (see p. 5).

This arrangement of the families, like all other key plans and schemes of a similar kind, does not represent exactly the phylogenetic sequence of the Pennatulacea, although it begins with the Veretillidae which I regard as the most primitive and ends with the Pteroeididae which I regard as the most specialised of the families of the Order.

A warning should also be issued to those who may use this arrangement for the purpose of the identification of species that there are some exceptional cases in which it might be misleading. I will therefore add a few comments, which although of the nature of a criticism of the scheme as a key plan will have the effect of rendering it more useful to the students of the group. The Veretillidae have a radially symmetrical rachis except in a few specimens of *Actinoptilum molle* described by THOMSON (1915 p. 7) in which there is a short ventral (?) track indicating incipient bilateral symmetry. All the other Pennatulacea have a bilaterally symmetrical rachis, that is to say there is a longitudinal track on the dorsal or ventral (Echinoptilidae) surface of the rachis, or on both dorsal and ventral surface that is free from autozooids. These tracks enable us to distinguish the lateral from the dorsal and ventral surfaces of the rachis, and in most cases the dorsal with the wide track from the ventral surface with the narrower track. The only exceptions to this are to be found in some specimens of *Sclerobelemnon Burgeri* in which a few autozooids occurring on the dorsal track, obscure the bilateral symmetry; and in *Echinoptilum echinatum* in which according to KÜKENTHAL and BROCH (1911 p. 199) a small percentage of specimens show no ventral track. In *Echinoptilum* however the bilateral symmetry is also shown by the greater size of the autozooids on the dorsal surface of the rachis.

The Echinoptilidae and the Renillidae are distinguished from all the other bilaterally symmetrical Pennatulacea by the entire absence of the axis. Among the radially symmetrical Pennatulacea *Actinoptilum* and some species of *Cavernularia* have no axis. The bilaterally symmetrical Pennatulacea with an axis are much more difficult to arrange in groups as there is considerable overlapping of the families as regards any one character.

In the Kophobelemnonidae, for example, an arrangement of the autozooids in indistinct longitudinal rows may often be observed and in *Sclerobelemnon Gravieri*, there may be a single longitudinal row of autozooids on each side of the rachis as in some of the Protoptilidae (e. g. *Distichoptilum gracile*) and the resemblance is increased by the presence in that species of rudimentary but quite distinct verrucae.

These two families (The Kophobelemnonidae and the Protoptilidae) provide an interesting example of the way in which two families may come into close contact. No two genera could be more distinct than *Kophobelemnon* on the one hand and *Distichoptilum* on the other and

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yet in the genus Sclerobelemnon we find a species which in external characters seems to link the two families together.

Moreover in the Anthoptilidae, although the autozooids are usually arranged in transverse or oblique rows, in young forms and in *Anthoptilum Kükenthali* they have the appearance of being irregularly distributed on the rachis.

In the group to which the Anthoptilidae belong we find similar difficulties. In both the Pavonariidae and the Anthoptilidae the autozooids of a row may or may not be united at their bases to form primitive leaves but very rarely are all the autozooids of a row thus united. In the Virgulariidae we find a long series of cases from *Virgularia gracillima* in which there are only a few autozooids for the most part free but united or webbed together at their bases to form a primitive leaf to *Virgularia Gustaviana* in which there are numerous autozooids united together for the greater part of their length to form large well developed leaves.

If we took the presence or absence of well developed leaves as the sole character for distinguishing families, *Virgularia Gustaviana* would certainly have to go back into its old genus *Halisceptrum* and be classified with the Pennatulidae.

The distinction, given in the table, between the Pavonariidae and the Anthoptilidae is admittedly not very satisfactory partly because it is based on insufficient anatomical investigation and partly because from the point of view of the systematist it is impossible to determine without microscopical study and injury to the specimen as a whole.

It is, as a matter of fact, very difficult to separate these two families, as the genus *Osteocella* forms an almost perfect connecting link between them and it is very probable that the two families will, after further research, be amalgamated.

There is usually no difficulty in distinguishing the members of the last two families in the list by the presence or absence of siphonozooids on the leaves. In the case of *Sarcophyllum* however it is a matter of interpretation rather than of fact whether the "stipules" on which the siphonozooids are found are, or are not, morphologically a part of the leaves. In young specimens of *Sarcophyllum* before the stipules are properly developed the group or pad of siphonozooids appears to be clearly on the dorsal track and not on the leaf. In large full grown specimens however the statement that the siphonozooids are on the leaves is apparent.

In the list given below will be found the names of all the genera of the Pennatulacea that are regarded in this Memoir as good. A list of generic names which, in my opinion, should now be regarded as synonyms is given on p. 33.

Veretillidae	*Lituaria* Val.
	Veretillum Cuv.
	Cavernularia Val.
	Actinoptilum Kükenthal.
	Stylobelemnoides Th. & H.
	Parabelemnon Th. & S.
Echinoptilidae	*Echinoptilum* Hubrecht.
Renillidae	*Renilla* Lam.
Kophobelemnonidae	*Kophobelemnon* Asbj.
	Sclerobelemnon Köll.
Funiculinidae	*Funiculina* Lam.
Protoptilidae	*Protoptilum* Köll.
	Distichoptilum Verrill.
	Helicoptilum Nutting.
Chunellidae	*Chunella* Kükenthal.
	Scleroptilum Köll.

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Umbellulidae	*Umbellula* Cuv.	Pennatulidae	*Pennatula* Linn.
Pavonariidae	*Pavonaria* Köll.		*Leioptilum* Gray.
	Osteocella Gray.		*Scytalium* Herk.
Anthoptilidae	*Anthoptilum* Köll.		*Acanthoptilum* Köll.
Virgulariidae	*Virgularia* Lam.	Incertum sedis	*Stachyptilum* Köll.
	Stylatula Verrill.	Pteroeididae	*Pteroeides* Herk.
Incertum sedis	*Stephanoptilum* Roule.		*Sarcophyllum* Köll.
			Gyrophyllum Stud.

Genus *Stachyptilum*. The position of this genus is difficult to determine from the accounts that have been published and as I have had no opportunity of studying any specimen except the type specimen in the British Museum, I can add nothing to our knowledge of its structure.

It includes a number of bilaterally symmetrical fleshy sea pens with a complete axis and with the autozooids arranged in transverse rows of four of five individuals. There is a rich armature of spicules some of which are ridged needles.

The difficulty in placing the genus may be seen in the difference of opinions expressed by the leading authorities. KÖLLIKER (1880 p. 11) placed it in his sub-section Funiculineae next to *Anthoptilum*, JUNGERSEN (1904 p. 8) regarded it as one of the Pennatulidae whereas BALSS (1910 p. 36) considered it to be related to the Echinoptilidae. KÜKENTHAL & BROCH (1911 p. 259) have, more recently, given a detailed account of a specimen of *Stachyptilum superbum* and place the family Stachyptilidae next to the Protoptilidae in the section Pennatulacea bilateralia. Notwithstanding this, however, I am inclined to the view that the nearest affinities of the genus are with the Pennatulidae

Stachyptilum has been found in the Indian and Pacific Oceans at depths of 46—950 metres.

Genus *Stephanoptilum*. The true position of this genus cannot be definitely determined until a more complete description with figures has been provided. From the preliminary account by ROULE (1905 p. 455) it seems to be related to *Virgularia*, particularly to those species such as *V. Roulei* (p. 168) in which the autozooids composing the leaves have a tendency to be arranged in tufts or bouquets (Στεφανος). As in *Virgularia* there are no spicules in the rachis.

Three specimens were obtained by the Talisman Expedition in the Atlantic Ocean at depths of 930—2000 metres.

STRUCTURE AND TERMINOLOGY.

There is so much confusion in the use of technical terms in the literature of the Alcyonaria that it is necessary to make some explanation, at the outset, of the way in which they are used in this memoir. In the absence of any central authority with power to determine the use of terms writers will doubtless continue to be guided by their personal predelictions and national customs and it is unlikely that any scheme of complete uniformity will be matured.

I should like however to express in a few words the reasons why I have used the terms

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employed in my work in the hope that they may lead to a greater measure of uniformity than exists at the present day.

In the literature of the Coelenterata we find that the individual animal that is developed from the fertilised egg is usually called "a Polype" — a word originally suggested by RÉAUMUR and used by TREMBLEY (1744) for Hydra which he called the "Poulpe" or "Polype d'eau douce". In the case of those Coelenterata in which the original individual gives rise to a colony by budding, the individuals are generally called "Polyps" when they are of large size and of the same kind or "Zooids" when they are of small size or of different kinds.

There has been no general consistency in their use, but the two words "polype" and "zooid" have been used throughout the literature of the phylum as synonyms for the individual of a colony, except in the Order of the Pennatulacea in which since the time of KÖLLIKER (1870) he and some other authors have used the term "polype" to mean one kind of individual and "zooid" to mean another. In other words the two words have had a definitely restricted meaning in the Order Pennatulacea and a general meaning in all the other orders of the same Class.

The inconsistency of this is obvious and has frequently been pointed out by English authors; the inconvenience, however, does not seem to be apparent to many of those concerned with the systematics of the group. Many examples could be quoted to show the inconvenience of the conversion of a general term into one with a restricted meaning but a reference to one will be sufficient.

In the general account of the characters of the Sea Pens KÖLLIKER (1872 p. 5) says "Die Polypen oder Einzelthiere treten bei allen Gattungen der Pennatuliden in zwei Formen auf....".

In this sentence the word "Polypen" is obviously used as a general term for individuals of the colony but in a subsequent page he suggests that the word should be restricted in its use to the "sexual polyps" and there is no separate term left in his vocabulary for the individuals generally of the colony.

The result is that, as a matter of fact, he uses "Polyp" some times with a general and some times with a restricted meaning. Thus "Polypenträger" is the bearer of all kinds of polyps, and in the following sentence (p. 313) the word Polypen has or should have reference to both kinds of individuals: "Veretilliden bei denen der Kolben ringsherum mit Polypen besetzt ist". Whereas in the systematic description of the genera and species the word "Polyp" refers only to the sexual individual and "Zooid" to the rudimentary sexless individual of the colony.

It is quite clear then that if we wish to refer in concise language to individuals of a colony which show some special character or peculiarity it is necessary either to modify the general term used for such individuals by a prefix or to suggest a new name altogether. By common consent, I think, the former of these two methods is to be preferred. In the case of dimorphic or polymorphic colonies of Coelenterates there would be historical grounds for selecting either of the two words as the root word but preference has been given in the past to "Zooid" for making the compound word and it is most convenient for many reasons to use it still. As already pointed out by BOURNE (1900 (2) p. 522) the root word "Zooid" lends itself more readily and euphemistically to descriptive prefixes than the word "Polype" and has almost invariably been used in this way by previous authors.

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The sea-pen, being a colony, will be described therefore as formed by a number of "zooids".

The zooids of the Pennatulid colony are of three or four kinds.

The three kinds that are found in the colonies of all species are called, the "oozooid" the "autozooids" and the "siphonozooids". In the colonies of some species a fourth kind of zooid is found which I propose to call the "mesozooid".

The "oozooid" (Oozooite of DE LACAZE DUTHIERS, Haupt-polyp, axial zooid) is the first formed zooid of the colony and the direct product of the fertilised ovum. It undergoes remarkable changes in structure during its development, gives rise by gemmation on its body wall to all the other zooids of the colony and forms the greater part of the rachis and stalk of the adult colony.

The zooids composing the colony of nearly all Alcyonaria consist of two parts or regions; a distal region, the "anthocodia" (BOURNE 1900 (2)) [1]) bearing the mouth, tentacles, stomodaeum etc. which is free and can usually be partly or wholly retracted and a proximal or basal region the "anthostele" which may either be fused with the corresponding region of other zooids, or, if free, thick and not retractile.

The "anthocodia" of the oozooid in the Pennatulacea usually undergoes degeneration soon after colony formation by gemmation begins, although it may be represented in some cases by the so-called "terminal zooid" of young colonies. The history of this part of the oozooid, has been described in the development of Renilla (WILSON 1883), Pennatula (JUNGERSEN (1888) and Umbellula (WILLEMOES-SUHM 1875) but our knowledge of its fate is still very far from being complete.

The "anthostele" on the other hand becomes very much enlarged and continues to grow in length and bulk throughout the life of the colony. It may be divided into two regions, an upper or distal region on which all the other zooids of the colony are formed by gemmation which is called the "rachis" and a lower or proximal region which does not usually produce any zooids and is imbedded in the mud at the bottom of the sea when the colony is alive, which is called the "stalk" (fig. 1).

The word "rachis" has not been used consistently in previous writings. The rachis must be taken to include the whole of all the zooids of which it is composed.

In *Pennatula* and *Pteroeides* for instance it must be taken to include the leaves however large they may be. It is synonymous with the german word "Feder" but not with the words "Kiel" or "Polypenträger" as used by KÖLLIKER, for "Feder" always includes the leaves whereas "Kiel" or "Polypenträger" sometimes does and sometimes does not.

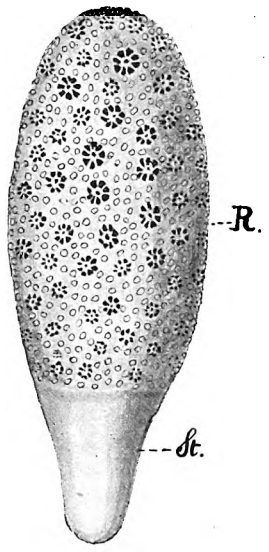

Fig. 1.
A radially symmetrical sea-pen (*Cavernularia*) showing a clear line of demarcation between the Rachis (*R.*) and the Stalk (*St.*).
After KÖLLIKER.

1) I wish to call the special attention of students of Alcyonaria to the able and scholarly discussion of the morphology of the colony given by BOURNE in his paper "On the genus *Lemnalia*" (1900). To this paper we are indebted for many new exact terms and for placing our terminology on a sound scientific basis. I fail to understand the meaning of the remark made by KÜKENTHAL and BROCH (1911, p. 114) that the terms suggested in that paper can be "rejected as superfluous ballast".

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In the Veretillidae and in some of the other more primitive Pennatulacea the autozooids are not united to form leaves and the term Rachis (Kiel, Polypenträger) has been always used, with reference to them, to include the autozooids, it is surely then inconsistent, when dealing with the Pennatulidae and Pteroeididae, to give to this term the more restricted application to the part of the colony that bears the leaves, as is the usually the practice with writers on Pennatulacea. Any attempt to restrict the use of the term Rachis to the anthostele of the oozoid apart from the zooids it produces would lead to very great difficulties.

In most of the Pennatulacea the autozooids are not formed on the dorsal and ventral sides of the rachis but only on its lateral sides. I have used the expressions "dorsal track" and "ventral track" for the surfaces of the rachis that do not bear autozooids (fig. 2).

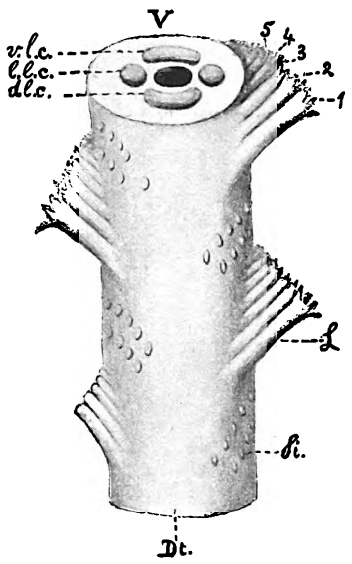

Fig. 2.

Diagram to show the structure of the rachis of a bilaterally symmetrical sea-pen. The dorsal side is exposed to view, only the upper edge of ventral side "V" is seen. *L.* the leaves. *1*, *2*, *3*, *4*, *5* the numerical sequence of the autozooids composing a leaf. *Si.* the siphonozooids. *Dt.* the dorsal track extending the whole length of the rachis between the dorsal edges of the leaves. *d.l.c.*, *l.l.c.* and *v.l.c.* the dorsal, lateral and ventral longitudinal canals. In the centre of the rachis, surrounded by the four longitudinal canals is seen the axis in section.

Modified from a drawing by JUNGERSEN.

The correct determination of the dorsal and ventral surfaces of *Pennatula* was made by JUNGERSEN in his embryological investigations (1888). He showed that, in the formation of the leaf the autozooids are formed in succession from the dorsal to the ventral aspect of the oozoid. The track that lies between the oldest autozooids of the leaves is therefore the morphological dorsal surface of the rachis and as these autozooids usually represent the longest edge of the leaf it is not difficult to recognise in the genus.

It is unfortunate that KÖLLIKER (1872) called this surface the ventral surface in a purely arbitrary manner, and therefore his nomenclature is just the reverse of that of JUNGERSEN and subsequent authors.

BOURNE, THOMSON and others use the terms "prorachidian" for dorsal and "metarachidian" for ventral. This change does not appear to me advisable. It is true that the word dorsal as applied to the Anthozoan polype does not have the same meaning as it does when applied to an Arthropod or to a Vertebrate animal but "prorachidian" is no better because it does not signify what is morphologically the anterior end of the colony. The Coelenterate colony, like the Coelenterate individual is built up on a radially symmetrical scheme and it has no front and hind ends any more than it has true dorsal and ventral surfaces.

It has been a recognised convention, however, to call that side of an Alcyonarian polype on which the muscle bands of the mesenteries face outwards the dorsal side and the opposite side the ventral. It has not been a convention to call them front and hind sides respectively.

Whereas the dorsal and ventral surfaces of a sea-pen with well developed leaves are easy to determine in some of the others their determination is little better than a guess.

In Echinoptilidae for example it is usually assumed that the surface on which there is a groove free from autozooids is the ventral surface as the autozooids at the sides of this

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groove are younger and smaller than those on the opposite side of the rachis, but the position of this family in the Order renders it difficult to accept this assumption as necessarily correct.

In the Renillidae the under surface of the curious leaf shaped rachis has been clearly shown, by the embryological researches of WILSON (1883) and JUNGERSEN (1888) to be ventral to the upper surface but the upper surface corresponds in the main with the two lateral surfaces of the rachis of other sea-pens, the dorsal surface being abbreviated and terminating only a short distance above the insertion of the stalk at the exhalent zooid (Terminal-zooid).

In the Veretillidae the complete radial symmetry of the adult colony makes it impossible to determine the surfaces (Text fig. 1) by external examination.

The stalk. (Stiel, Peduncle) is that part of the anthostele of the oozooid which does not usually bear zooids and in life is partly or wholly imbedded in the mud at the bottom of the sea.

In most of the families there are no zooids at all on the stalk but in the Umbellulidae very small but true siphonozooids have been described on that part of the stem (see p. 117) which is usually regarded as the stalk and in *U. Carpenteri* I found (1907 p. 13) siphonozooids even on the basal bulb. In some of the Chunellidae microscopic sections show small siphonozooids far below the region where macroscopic appearances would suggest that the rachis ends. These rather exceptional cases of zooids occurring on the stalk only show that the distinction we draw between stalk and rachis is really only an artificial distinction and not one that signifies, necessarily, an abrupt morphological change in the character of the anthostele of the oozooid.

The upper part of the stalk may show an oval swelling, usually due to the presence of a sphincter muscle and this is called the "upper" or "sphincter" swelling, and the lower or terminal end frequently exhibits a thin walled spherical or oval expansion called the "end bulb" or basal swelling (End-blase). The end bulb is so frequently broken and collapsed in the capture of the specimens that it is seldom of use for the diagnosis of species.

The autozooids[1]). ("Polypen" of KÖLLIKER) are the zooids of the colony which retain through life the typical eight pinnate tentacles, stomodaeum, mesenteric filaments and musculature of the Alcyonarian zooid. In all Pennatulacea so far as is known it is the autozooids alone that bear the gonads, and they are therefore sometimes spoken of as the sexual zooids.

The autozooids may arise independently from the rachis or their anthosteles my be united together in rows.

The rows of united autozooids are called in this memoir — the Leaves (German "Blätter").

In some treatises in the English language the words "pinnules" (E. g. KÖLLIKER's Challenger report) or "pinnae" are used, but as these terms must also apply to the lateral processes on the tentacles it seems to me that "leaves" is preferable.

In the Pennatulacea that possess well developed leaves there is a sharp distinction between the anthocodia of the autozooid and its anthostele. The former projects from the edge of the leaf bearing the mouth and crown of tentacles and can usually be completely retracted. The anthostele on the other hand is a component of the leaf itself. In the Virgulariidae and Anthoptilidae where the leaves are usually imperfectly developed, a considerable part of the

1) We are indebted to MOSELEY (1881 p. 118) for the terms "autozooid" and "siphonozooid".

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anthostele may be free (Plate VII fig. 43). In none of the Pennatulacea except Pteroeididae that I have examined is the leaf composed of anything but the anthosteles of the autozooids.

In the family Pteroeididae the siphonozooids also enter into the composition of the leaf but in no case have I found that the "spongy" tissue of the oozooid, projecting into the leaf, forms an essential constituent of its structure. In *Sarcophyllum* and in some species of *Pteroeides* belonging to this family a group of siphonozooids may extend on to the dorsal track of the rachis forming a ridge or pad at its dorsal edge. The ridge I propose to call the "stipule" (Pl. V, fig. 34). ("Nebenblatt" of KÜKENTHAL and BROCH).

In the Pennatulacea that do not form leaves the distinction between the anthocodia and the anthostele of the autozooids is not always clearly marked. In some species of *Anthoptilum* for example the distal part of the autozooid does not seem to be retractile at all and passes gradually into the basal part. In all cases however the proximal end of the autozooids is sunk into the substance of the oozooid and this part whether it is very short, as in Pennatulidae, or of considerable length, as in Umbellulidae, must be regarded as a part of, if it is not the whole of the anthostele.

The Siphonozooids are the zooids of the colony that remain in some respects in an imperfectly developed condition and in another become specially modified in structure to perform their special functions. In some of the Umbellulidae and Chunellidae they may possess one tentacle but in the vast majority of cases they have no tentacles at all. They may or may not possess the two dorsal mesenteric filaments but the other mesenteric filaments are never developed. The mesenteries do not support visible retractor bands of muscles and are often only partially developed.

In the Pennatulacea they never bear gonads although in some other dimorphic Alcyonaria (e. g. *Corallium*, *Paragorgia* etc.) they are the sexual zooids.

The only way in which they are specialised is in the great widh and extent of the siphonoglyph in the stomodaeum. In a transverse section the epithelium on the ventral side of the stomodaeum extending as far as the insertion of the ventro-lateral mesenteries is seen to be very thick and to support a large number of long powerful cilia. In a longitudinal section this modified epithelium is found to extend the whole length of the stomodaeum.

The two (ectodermic) dorsal mesenteric filaments are in some cases present in others entirely absent. WILSON (1884 p. 18) states that according to the researches of KÖLLIKER these filaments are present in the siphonozooids of all the genera except *Leioptilum*, *Sarcophyllum*, *Virgularia*, *Acanthoptilum* and *Renilla*, but this statement does not cover the whole of the facts of the case. KÖLLIKER (1872 p. 38), it is true, states that they are present in *Pteroeides pellucidum* but adds the qualifying remark "Doch sah ich sie bei einzelnen Individuen auch fehlen und weiss ich nicht, ob denselben ein allgemeines Vorkommen bei den verschiedenen Arten zuzuschreiben ist". Since that date NIEDERMEYER (1911 p. 36) has stated that he could not find the mesenteric filaments in the siphonozooids of *Pteroeides griseum*. On examining a series of preparations of *Pt. malayense*, *Pt. caledonicum*, *Pt. timorense* and *Pt. argenteum* I could find no trace of dorsal mesenteric filaments but in a similar preparation of *Pt. Steenstrupii* they were present and of considerable size.

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In the genus *Pteroeides* therefore they are sometimes present and sometimes absent. This is also true for *Umbellula* and *Pennatula*. In the large siphonozooids of the petaloid areas of *U. Carpenteri* these filaments are present and well developed but in the small siphonozooids of the stem and stalk they are absent. In the siphonozooids of *Pennatula phosphorea* (MARSHALL 1882 p. 46) they are present and also in those of *P. grandis* but in the siphonozooids of *P. Murrayi* they are absent (see p. 195).

A further study of the distribution of the dorsal mesenteric filaments in the siphonozooids of Pennatulacea might yield results of considerable interest and importance.

The Mesozooids. I have suggested this name for certain zooids, found only in a few species of Pennatulacea, which are different in structure from both the autozooids and siphonozooids and appear to be exhalent in function. They have been found only in *Pennatula Murrayi*, *P. grandis* and in several species of *Pteroeides* (the "Rhachidiozooids" of NIEDERMEYER) but it is possible that the exhalent zooid of *Renilla* and the zooids called "Scheitelzooiden" by JUNGERSEN (1888 p. 638) of the young colonies of *Pennatula phosphorea* are of the same kind.

The mesozooids of *Pennatula Murrayi* (Pl. IX, fig. 66 *mes.*) are on the dorsal side of the rachis, those of *Pteroeides* are on the ventral side but their remarkable similarity in structure shows that they must be analogous even if they are not strictly homologous zooids.

The mesozooids have no tentacles. They have a large open stomodaeum with a weak siphonoglyph supported by eight mesenteries provided with strong muscle bands (see p. 196 and Pl. VIII fig. 57). They possess no mesenteric filaments nor do the mesenteries bear gonads.

The function of the zooids. The main functions of the autozooids are obviously to catch, ingest and digest the food and to produce and nourish the gonads. It is probable that the short weak siphonoglyph that is usually found in these zooids produces but a feeble inhalent current of water and that the current in the opposite direction produced by the cilia on the dorsal mesenteric filaments is not of much importance in the rapid discharge of water from the canal systems.

The main function of the siphonozooids is to produce inhalent currents of water for the distension of the canals. In my studies on *Alcyonium* (1883 p. 694) I showed that the function of the siphonoglyph is to produce an inhalent current of water and of the dorsal mesenteric filaments to produce a current in the opposite direction. WILSON (1884) confirmed my results as regards the currents produced by the dorsal mesenteric filaments in his study of living specimens of *Veretillum* and other Alcyonaria bud did not apparently observe the cilia of the siphonoglyph in action.

The large siphonoglyph armed with powerful cilia that forms such a characteristic feature of the structure of the siphonozooids suggests that the main function of these zooids is inhalent and this is confirmed by the observation that in nearly all cases the mouth of the siphonozooid of preserved specimens is closed. If they were to any extent exhalent in function we should expect them to open when they pass through the agonies of capture and preservation.

However the fact that in many species the siphonozooids are provided with dorsal mesenteric filaments renders it possible that there is during life in such species a flow of water along the dorsal angle of the stomodaeum from within outwards as in the Alcyonium polyp.

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The function of the mesozooid is to allow the passage of exhalent currents. This is shown by the large stomodaeum with a very weak siphonoglyph and by the fact that the mouth is always open in preserved specimens. Moreover we have the direct evidence of KÜKENTHAL (1909 p. 325) that in living *Pteroeides griseum* the mesozooids produce strong exhalent currents.

The absence of mesenteric filaments seems to indicate that these exhalent currents are not so much produced by ciliary action as by the muscular contractions of the rachis and stalk and that they come into action principally when the colony is withdrawn into the mud or violently contracted when caught by the dredge or plunged into the preservative fluid.

It is probable that in those Pennatulids that possess these mesozooids the expiratory currents in the siphonozooids are not necessary and that this accounts for the absence of the dorsal mesenteric filaments in the siphonozooids of *Pennatula Murrayi* and many species of *Pteroeides* and their presence in *Pennatula phosphorea* and many other species in which the mesozooids do not occur. The absence of dorsal mesenteric filaments in the siphonozooids of *Virgularia* may be accounted for by the fact that the distal end of the rachis in that genus is almost invariably missing (broken off or bitten off) and the water may be discharged in violent contraction by the open ends of the four great longitudinal canals.

On the other hand in the very fleshy species *Pennatula grandis* which possesses mesozooids there are dorsal mesenteric filaments in the siphonozooids (see p. 183).

The Calyx is the upper free part of the anthostele of an autozooid which is usually thickened and lobed in the early stages of the retraction of the anthocodia and constricts to

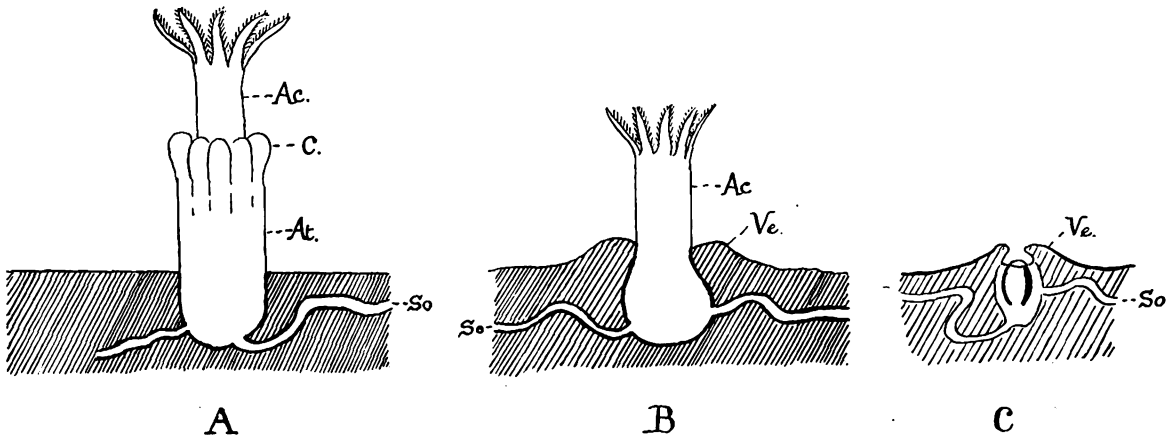

Fig. 3.

A Diagram to illustrate the formation of a true calyx with the anthocodia shown in the first stage of retraction. *Ac.* Anthocodia. *At.* Anthostele. *C.* Calyx. *So.* Solenia.

B Diagram to illustrate the formation of a verruca. Lettering as in A with *Ve.* Verruca.

C Diagram to illustrate the verruca of a siphonozooid.

protect the zooid when the anthocodia is completely retracted. JUNGERSEN's definition (1910 p. 24) of the calyx as "the hinder part of the polyp body which is rather stiff so that the fore part with the tentacles may be retracted into it", does not seem to me sufficiently precise and would lead to confusion in some genera (e. g. *Anthoptilum*) if generally accepted. The calyx may be armed with spicules or it may not, it may be provided with 1—8 pointed processes — the calyx teeth; or support groups of projecting spicules — the calyx spines. The use of the term "cell" for a calyx that does not bear spicules as in the genus *Virgularia* (BALSS 1910

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p. 43) is not to be recommended. BOURNE (1900 (2) p. 523) has suggested the term "anthocrypt" for the calyx but it does not seem to me that in this case a new term is really necessary.

The Verruca is the term used for a collar-like swelling or prominence of the general surface of the rachis (i. e. a part of the body wall of the primary oozooid) for the protection of the zooids. It may be difficult in some cases to distinguish between a true calyx and a true verruca without microscopical investigation but there is an essential morphological difference between them in so far as the calyx is formed by the autozooid and the verruca by the oozooid (Compare fig. 3 *A*, *B*, *C*).

Thus the "pseudocalices" or "small calices" of the siphonozooids are in all cases "verrucae". The structures called calices of the autozooids of *Parabelemnon* and *Stylobelemnoides* are probably verrucae. The so-called "calices', of the autozooids of *Actinoptilum* are verrucae but the calices of the autozooids of *Echinoptilum* are true calices.

The Axis is the horny and calcareous skeletal rod that is usually found in the middle of the colony. It is unfortunate, perhaps, that the same term is also used for the main shaft of the tentacle from which the pinnules arise but no confusion need arise if, in this case, the full expression "axis of the tentacles" is always used.

Canals and Cavities. It is not proposed in this memoir to deal very fully with the anatomy of the species described but the use of the terms used must be explained. In the centre of the rachis of the colony there are usually found four large longitudinal cavities surrounding the axis sheath. These are called the dorsal, ventral and lateral (right and left) longitudinal canals respectively (textfig. 2 p. 8).

The cavities of the zooids (autozooids, siphonozooids, and mesozooids) are called the "coelentera" or coelenteric cavities. These cavities do not usually, if ever, communicate directly with the longitudinal canals but indirectly by anastomosing canals lined by endoderm called the Solenia (BOURNE). These are the same as the "nutritive" or "endodermal" canals of previous authors. In certain genera some of the solenia show a histological differentation in so far as that the cells are smaller and more closely set to form a definite ciliated epithelium. These canals are arranged radially on the dorsal side of the axis in Virgularia, Anthoptilum and Stylatula, and on the ventral side in Osteocella (Text figs 30, 31, p. 147). They are called the radial canals (KÖLLIKER 1872).

In *Pennatula Murrayi* similar canals on the dorsal side of the axis but much more in regularly scattered are called the "brown tubes" (Pl. IX, figs 65, 67, 68 *b. t.*).

ON THE CHARACTERS USED IN CLASSIFICATION.

In dealing with the genera and species of such a group as the Pennatulacea the systematist meets with the great difficulty, arising from the uncertainty of the value of the characters used in classification. He finds that one authority pins his faith on the shape and proportions of the colony, another on the form and distribution of the spicules, another on the distribution of the zooids and so on, but there is no clear course to adopt that is free from the destructive criticism of authorities of equal weight.

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Taking the group as a whole, there can be no doubt that every character is liable to considerable fluctuations and that no one character can be trusted to give a good key to the division into families, genera and species. Nevertheless characters which are variable in one family or genus may be far less variable in another; they may be useless for systematic work in the former case and very valuable in the latter. It is the duty of the systematist to find out what characters of his genus or species are very variable and what are not and base his system as far as possible upon those characters within a group of related specimens which show the least variability.

If we take any one genus we find that there are certain characters that are plastic (HICKSON, 1903 (1) p. 682) that is to say are liable to very considerable variations in the species, others on the other hand that are rigid and show essentially the same features in all the species. For example in the genus *Pennatula* the colour, the shape of the leaves and the size of the spicules are very variable or plastic characters but the cylindrical axis, the 3 flanged (dreiflügelig) needle shape of the spicules and the absence of siphonozooids on the leaves are fixed or rigid characters.

But what is true for these characters in *Pennatula* is not true in all the genera of Pennatulacea and we find many examples of what we may suppose to have been at one time in evolution, plastic characters that have become rigid and perhaps also some cases of rigid characters that have become plastic again.

I may quote one of two cases to illustrate this point. In the genus *Pennatula* an axis is always present, thousands of specimens have been examined and there is no record of a specimen that did not possess a complete cylindrical axis. In *Funiculina* again there is always a complete axis and it is invariably square or quadrangular in section. In *Cavernularia* on the other hand there are great variations in the axis. It is sometimes present, sometimes absent and frequently short or incomplete. So variable is it in this genus that BALSS (1910 p. 86) considers it should not be used as a character for the separation of species.

In the genus *Scytalium* the spicules of the rachis are always small discs which vary in size from 0.04—0.06 mm. in length (Text fig. 38 p. 206). They never reach a greater size and vary very little in shape. They form in fact a most valuable and certain character for the determination of the genus.

In the genus *Sclerobelemnon* on the other hand the spicules of the rachis present us with a most remarkable case of variation both in shape and size. In two specimens of *Sc. Burgeri* for example collected at the same station at the same time and approximately of the same size, the large spicules of one were 0.4 mm. in length of the other not more than 0.04 mm. in length. In the case of two specimens of *Cavernularia orientalis* collected at the same time from the same station and also of approximately the same size the spicules of one were, with a few exceptions, smooth flat needles terminating in simple points those of the other were flat needles bifurcated or branched at the extremities (Text figs. p. 53).

From these examples it can be seen that a character which is of the utmost value for the determination of a genus in one family or of a species in one genus may be valueless in the determination of genera in another family or of species in another genus. The determination

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of which characters are plastic and of which characters are rigid can only be made when a considerable number of specimens have been examined and preferably of specimens from the same locality. Thus when a single specimen of a new type comes to hand, it may be measured and described in detail but until it has been compared with other specimens of the same type the determination of the characters that are really diagnostic as a new genus or species cannot be made. For example KÜKENTHAL and BROCH (1911 p. 172) described as a new genus (*Cavernulina*) of Veretillidae a single specimen obtained in shallow water from Amboyna on the character that the spicules are branched at the ends. An examination of four specimens from the same locality (p. 52) has shown that in this form the spicules are extraordinarily variable and the specimens cannot be separated from the genus *Cavernularia*.

In the Siboga collection there is from Stat. 251 a single large specimen of the genus *Echinoptilum* which I have placed, provisionally, in a new species, *E. roseum*. It is quite probable that when more specimens of this form from the same and other localities are examined it may prove not to be a distinct species.

All the characters on which the four species of this genus collected by the Siboga expedition are founded may be variable and there were not enough specimens of three of the species to determine to what extent the characters have become rigid. There were forty specimens of *Echinoptilum minimum* which, so far as they were tested, showed constant characters but as they were all very small in size, they may have been juvenile and represented the young stages of other species.

We may now consider in detail the value of some of the characters that are used in the classification of the Pennatulacea.

Measurements of the total length of the colony are obviously of only secondary value, as the total length varies with the age of the specimens. Nevertheless it is of some use in the determination of species, when a large number of specimens have been described.

The relative length of stalk and rachis is regarded by some authors to be of considerable value. It is, however, a character which, in several genera, it is difficult to determine with accuracy. As BALSS (1910 p. 13) has pointed out the exact length of the stalk of *Kophobelemnon* depends upon the method and conditions of preservation and the same may be said for the genus *Pteroeides* and for some of the genera of the family Veretillidae. NIEDERMEYER (1913 p. 264) has shown that in *Veretillum cynomorium* for example the relation of stalk to rachis character is valueless for classification.

In several genera, such as *Kophobelemnon*, *Umbellula* and *Virgularia*, it is impossible to measure accurately the length of the stalk without making several microscopic preparations to determine the exact point where the zooids of the rachis stop. The measurements in these cases are therefore in most cases determined by the general impression of the observer and are devoid of scientific accuracy. In *Pennatula*, *Gyrophyllum*, *Scytalium* and some others the measurement of the stalk can usually be determined with a fair degree of accuracy and when a large number of specimens of a species are collected in one locality and examined it is found that the ratio of length of rachis to length of stalk is almost constant. In a collection of 32 specimens of *Pennatula phosphorea* (forma *candida*) from the Mediterranean Sea, KÜKENTHAL and BROCH

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(1911 p. 371) found that the ratio of length of stalk to length of rachis is almost constant and in 30 specimens of *Scytalium Martensii* from Timor I have found a similar constancy in this ratio.

But there is reason to believe that this ratio is dependent to some extent upon depth or nature of the bottom deposit and is not a good inherent specific character. In deep sea forms the stalk is usually longer in proportion to the rachis than it is in shallow water forms. Thus in seven specimens of *P. Murrayi* from the Timor coast, 112 metres, the ratio of rachis to stalk was 3.5—5.5 : 1 but in 5 specimens of the same species from the Kei islands, 300 metres, it was only 2—3 : 1 (see p. 190).

The difference between these ratios suggests that the character is one that is dependent upon the environment but whether it is depth or the nature of the sea bottom that determines it, cannot at present be proved. It is a matter however that is worth further investigation when the opportunity serves.

A better character for systematic purposes is the ratio of length to breadth of the rachis. I have found it to be useful in *Pteroeides* and some other genera with formed leaves. It has however one obvious disadvantage and that is that it cannot be used for specimens that are clearly juvenile. When a large number of adult forms of a species of *Pteroeides* are measured it is found that the ratio of length to breadth of rachis is nearly constant and that this ratio differs when one species is compared with another. The ratio may to a slight extent depend upon the preservation but when the leaves are supported by a strong armature of spicules as in *Pteroeides* and *Pennatula* the variations due to preservation must be inappreciable.

At the best however the character is not a very valuable one.

The form and arrangement of the spicules of the rachis undoubtedly afford the best and most useful characters for the determination of species, but I cannot go so far as KÜKENTHAL and BROCH (1911 p. 156) as to assert that these characters are constant for each species.

In the higher Pennatulacea the form of the spicules of the rachis is of great value in the determination of genera. In the genus *Pennatula* for example the spicules are always 3-flanged (dreiflügelig) needles a little thicker in the middle than at the two extremities. A very large number of specimens and species have been examined and this characters appears to be constant. In *Pteroeides* the spicules are long needles of the same shape but without the flanges. In *Scytalium* they are small flat plates and in *Gyrophyllum* stout 3-flanged rods. But if we take a large collection of the spicules of one species of any of these genera and compare it with a similar collection from another species of the same genus there may be no sharp line of distinction between them.

It has unfortunately been the practice in the description of species to examine, draw and describe only a few spicules taken more or less at random from a small piece of the rachis and the difference between species as regards form and size of spicules is in this way unnaturally accentuated. To test this character I took a large number of spicules from specimens of *Pteroeides malayense* and *Pteroeides caledonicum* and compared them with the result that they were found to be almost alike. The largest spicules in the former were not so long as the largest spicules in the latter but the vast majority of the spicules were such as might have

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occurred in either species. A general impressison may often be obtained that the spicules of one species are different from that of another. Thus the spicules of *Pteroeides argenteum* are shorter and thicker than the spicules of *Pteroeides malayense* but a number of spicules could be selected from the former which could not be distinguished from a number of spicules selected from the latter.

The arrangement of the spicules in the rachis is often a character of value in the determination of species and genera.

Spicules may or may not be present in the tentacles of the autozooids and it is usually found that when spicules are present in this position in one specimen of a given species they are present in other specimens of the same size and vice versa.

In *Echinoptilum minimum* and *E. elongatum* spicules were not found in the tentacles of the autozooids, but in all the other species of the genus spicules were found in that position.

In *Pennatula Naresi* spicules occur in the tentacles, in *P. Murrayi* they do not. In the genus *Kophobelemnon* spicules always occur in the tentacles, in *Sclerobelemnon* they usually do not.

Similarly spicules may or may not occur in the body walls of the anthocodiae. KÜKENTHAL and BROCH (1911 p. 201) for example regard the presence of spicules in this position in *Echinoptilum echinatum* and their absence in *E. M'Intoshii* as an important point of distinction between the two species.

The character however is one that must be used with caution as there is some reason to believe that the armature of spicules varies to some extent with age.

GRIEG (1896 p. 7) has shown that in the younger stages of *Funiculina quadrangularis* there are spicules in the tentacles but in the older stages the tentacles have no spicules [1]).

It may be that this is an exceptional case and that there is no general law that applies in the matter. I know of no other example of a species that has a more complete spicular armature in the young stages than in the adult.

The arrangement of the spicules on the leaves in the higher Pennatulacea has also been used as a character of systematic value.

The genera *Stylatula* and *Virgularia* for example are distinguished from one another by the presence of spicules in the leaves of the former and their absence from the leaves of the latter although in other respects they are closely related. In this case the investigation of a very large number of specimens of both genera shows that the character is rigid.

Again, the genus *Pennatula*, with the exception of one species, is distinguished from *Leioptilum* by the distribution of spicules throughout the whole breadth of the leaves in the former and their restriction to the margin of the leaves in the latter but in this case *Pennatula fimbriata* shows an intermediate condition the spicules in some specimens being confined to the margins of the leaves but more widely distributed in others (p. 185).

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1) KÜKENTHAL and BROCH (1911 p. 249) dispute the statement of KÖLLIKER (1872 p. 250) and of GRIEG that there are no spicules in the tentacles of the adult *Funiculina quadrangularis* and state that there are small ridged spicules in the tentacles of all the specimens they have examined. I have re-examined the specimens of this species from Oban described by A. M. and W. P. MARSHALL (1882) and can confirm the negative evidence of their description that there are no spicules in the tentacles. I have examined the tentacles of several autozooids with a high power and can find no trace of the spicules described by KÜKENTHAL and BROCH.

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In *Pteroeides* the spicules of the leaves have a more definite plan of arrangement than in other genera, some of the larger ones being specialised to form the rays and it may be regarded now as an ascertained fact that any Pennatulacean showing rays in the leaves also shows the other characters of the genus *Pteroeides*. But even in this case there are some species in which the rays are not very well defined and might be variously interpreted.

In dealing with the species of this genus I have used the number of the rays in the larger leaves of full grown specimens as a character of specific value but I doubt whether it will stand the test of further investigations. As regards the arrangement of the spicules between the rays in this genus I can only say that so far as my own investigations have gone it seems to be so variable in the several leaves of a single specimen as to be worthless for systematic purposes.

The arrangement of the spicules on the parts of the rachis other than the leaves is usually a good character but there are some examples of remarkable variation in this respect.

In most of the Veretillidae and in *Sclerobelemnon* the number, arrangement and size of the spicules varies a great deal not only in different species but in specimens of the same species from the same locality.

Nevertheless in some forms of *Cavernularia* (fide KÜKENTHAL and BROCH), in *Actinoptilum* and in *Echinoptilum* the spicules of the rachis are far more constant. In the higher Pennatulacea the spicules of this region usually present a constant arrangement but there is a remarkable exception to this in the case of *Pennatula fimbriata* some specimens (from Stat. 289) showing the typical arrangement, others (from Stats. 251 and 256) showing very few spicules in this position (p. 186).

The number, size and arrangement of the spicules in the cortex of the stalk afford a valuable character for the separation of species in some genera (e. g. *Echinoptilum* and *Pteroeides*) but in others (e. g. *Umbellula* and *Virgularia*) where they are reduced to minute calcareous corpuscles or groups of corpuscles they seem to be degenerating and are worse than useless for systematic purposes. In the case of *Virgularia* my researches show that these small corpuscles may be very local in distribution, a sample section from one part of the stalk showing them and another sample section from a neighbouring part of the stalk showing none. In the usual course of procedure in determining species it is quite impossible to examine microscopically the whole of the cortex of the stalk and therefore a general statement that there are no spicules in this region, or that they have a certain size and arrangement is usually misleading or untrustworthy.

A similar remark applies to the spicules and corpuscles of the sub-cortical layers of the stalk as I have tested by careful examination of two or three species. KÜKENTHAL and BROCH (1911) in their careful and detailed descriptions of species usually give an account and figures of the spicules of the "Stielinnern" but I cannot agree with them that a random sample of the many tissues that lie below the cortex of the stalk affords a character that is of any value at all.

When the spicules of the cortex of the stalk are definitely formed spicules (i. e. rods, needles, ridged needles etc.) as in *Echinoptilum* and *Pteroeides* and not merely degenerate

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irregular corpuscles they are much more constant in size and distribution and can be used as a supplementary specific character.

Spicules. There is so much variety in the shape of the spicules that it is difficult to separate them into a number of well defined groups but it is necessary to use some terms to express the form of some of the most pronounced types.

There are two of these types which are of special interest. The first is found only in the genus *Lituaria* one of the most primitive genera of all the Pennatulacea and is very similar to a type of spicule that is commonly found in the Alcyonacea. This spicule consists of two equal more or less spherical tuberculated knobs held together by a constricted cross piece. For this type of spicule I have used THOMSON's convenient term "capstan". These spicules are very similar in shape to the spicules described by KÖLLIKER (1865 p. 127) as "vielstrahlige Doppelsterne".

Fig. 4.
Lituaria Hicksonii.
"Molo" specimen.
Spicule of the rachis,
"Capstan" type.
× 160 diam.

The second type is found in certain genera of Pennatulacea but does not occur in any other Alcyonaria. It may be regarded as the most highly differentiated type of spicule found in the Order. This is a needle or spindle shaped spicule with three flanges or ridges running from end to end usually along lines that have a slightly spiral twist in relation to the axial line of the spicules. Spicules of this type were called "Gerippte Spindeln" by KÖLLIKER and "dreiflügelige" spicules by KÜKENTHAL. I propose to call them 3-flanged spicules.

In some cases the middle part of the spicule is thicker than the ends so that the shape is more correctly termed "spindle" than "needle" but more usually the diameter is almost uniform from one end to the other and then they are described as "needles". Shorter and thicker spicules with 3-flanges also occur and are called rods. When the spicules are spindle shaped the flanges or ridges may become very shallow or disappear in the thicker middle region of the spicules.

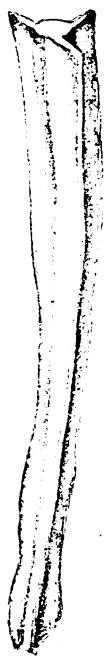

Fig. 5.
Diagram of one end
of a 3-flanged spicule
of *Pennatula indica.*

The 3-flanged type of spicule occurs in all species of *Pennatula*, *Echinoptilum* and *Gyrophyllum*. In a specimen of *Renilla* from the coast of California I have examined, most of the spicules are 3-flanged rods, but some of them have four flanges, and others additional imperfect ridges. In *Actinoptilum* also most of the spicules are 3-flanged but there are others in the rachis more irregularly ridged.

The spicules of *Kophobelemnon pauciflorum* also have longitudinal ridges but these ridges are not so pronounced as they are in the typical 3-flanged spicules of other genera and are much more variable in number. Moreover in this and other species of the genus the ends of the spicules are usually verrucose. Spicules of this type I have called ridged rods. KÜKENTHAL and BROCH speak of the spicules of *Kophobelemnon* as "dreiflügelig" but judging from the figures they give it seems to me the type should be distinguished from the typical 3-flanged spicule of such genera as *Pennatula* and *Echinoptilum*.

In addition to the capstans, 3-flanged and ridged-rod spicules of the Pennatulacea there

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is a fourth type with many variations. This is a flattened plate, frequently divided by a line into two parts or by lines into three or four parts giving us the twins, triplets and quadruplets of KÖLLIKER's nomenclature. The greatest variety of these forms is found in the radially symmetrical genera *Veretillum* and *Cavernularia* and in the genus *Sclerobelemnon* which with its incipient bilateral symmetry is closely related to the radially symmetrical genera (see text figs 8, 9 and 18, pp. 49, 53 and 84).

In some of these genera such as *Cavernularia* and *Sclerobelemnon* flattened rod shaped spicules with divided ends are formed which have a fancied resemblance in outline to a mammalian femur bone and have been called bone-shaped spicules. In *Scytalium* the spicules are small flattened discs or double discs. (Text fig. 38 p. 206).

In *Umbellula* and *Pteroeides* the spicules of the rachis are smooth rods, needles or spindles.

The study of the spicules of the Pennatulacea suggests that in the course of the evolution of the higher bilaterally symmetrical genera there has been a gradual change in the shape of the spicule probably along certain lines in adaptation to the greater muscular powers and increased turgescence of the sarcosoma.

Starting with the thick heavy capstan type of *Lituaria* inherited with but little modification from the Alcyonacean ancestor, we find the lighter flattened form of the other radially symmetrical genera, leading up to the flattened bone- and rod-shaped spicules of some of the species of *Cavernularia* and *Sclerobelemnon*. In the genus *Sclerobelemnon* there is a series of species showing less to greater bilateral symmetry and in this series we find the elongated rod-like forms of spicule becoming more numerous in the rachis as the bilateral symmetry becomes more pronounced.

The irregularly ridged rod and then the more definitely 3-flanged needle or spindle of the higher types of Pennatulids probably originated, from the flattened rod or needle of such a genus as *Cavernularia*. It is difficult to understand why the 3-flanged type of spicule should occur in such widely separated genera as *Echinoptilum* and *Pennatula* or how this type is specially adapted to their needs; but it seems certain that it was not monophyletic in origin. Along different lines of evolution *Pennatula* and *Echinoptilum* have acquired the same type of spicule.

The smooth spindle or needle shaped spicules of *Umbellula* and *Pteroeides* may be derived from the 3-flanged type of *Pennatula* or have originated independently from the flattened rod or needle. It seems to me more probable that it is derived from the 3-flanged type because in *Umbellula* the spicules of the rachis of many species are degenerating or absent and because the 3-flanged type occurs in *Gyrophyllum*, a genus which in some respects is intermediate between *Pennatula* and *Pteroeides*.

In addition to the spicules mentioned above a number of very small irregular round or oval calcareous corpuscles are found in the sub-cortical layers of the stalk of many genera. They are usually very irregular in size shape and distribution and I am inclined to regard them as degenerating spicules of no value for purposes of classification.

The arrangement of the autozooids on the rachis is used as a character for separating genera and species and in some cases for the separation of families. The autozooids may be situated all round the rachis as they are in the Veretillidae and in this case they may be arranged

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in more or less definite longitudinal lines or rows. Again in the Kophobelemnonidae where the dorsal track is always free from autozooids the longitudinal rows may be more or less definite. The distinction, however, that can be drawn between the conditions which may be called "irregularly scattered" "in indistinct rows" and "in distinct rows" do not seem to me to be sufficiently constant or definite to constitute a very sound specific character.

The arrangement of the autozooids in a single tuft or tassle at the distal extremity of the rachis evidently constitutes a good family character for the Umbellulidae, but the arrangement of them in a series of whorls as in most of the Chunellidae shows in one species a tendency to a more irregular arrangement (*Ch. Hertwigi* p. 110).

When the autozooids are fused together in transverse or oblique rows to form definite leaves a character is established which is constant in the higher familes of the Pennatulacea the Pennatulidae and Pteroeididae but in other families such as the Virgulariidae, Anthoptilidae and Pavonariidae there are intermediate conditions between a true leaf and a simple transverse row of autozooids. In *Virgularia halisceptrum*, for example, there is a true leaf composed of many autozooids with their body walls fused for the greater part of their length but in *V. rubra* there are very few autozooids with their body walls free from one another except for a narrow ridge at the base. In *Anthoptilum* some species show the autozooids free for their whole length, others with the autozooids united at the base to form leaves. In these families therefore the presence or absence of leaves is not a good family character.

The number of autozooids composing a leaf may be used in some genera as a supplementary specific character. In the genus *Scytalium*, for example, there is a considerable difference between the species as regards the number of autozooids composing the leaves of the adult specimens and in the absence of other good characters it becomes one of exceptional importance. In *Virgularia* also it is a valuable character but one of secondary importance.

The character however is subject to great variations according to age and according to the position of the leaf on the rachis. There can be no doubt that in all genera the number of autozooids per leaf increases with the age of the colony and that in a given colony the number of autozooids in the young leaves at the proximal end of the rachis is less than the number in the middle of the rachis. It is also found in some of the genera, if not in all of them, that the number of autozooids per leaf at the distal end of the rachis is also less than the number in the middle of the rachis.

In using this character for specific purposes therefore the number of autozooids in a leaf taken from the middle of the rachis should be counted and compared with the number of autozooids from the same region in other specimens or species of the same length. Any statement of the number of autozooids per leaf from other regions, or unaccompanied by a statement of the total length of the specimen is of very little use for systematic purposes.

The shape of the leaf is usually of very little use as a character. In *Pennatula phosphorea* for example we know from the researches of KÖLLIKER and subsequent authors that there is very great variation in the shape of the leaf within the range of the species. The insertion of the leaf (transverse to oblique) is a very variable character and cannot be used with much confidence. A good example of this variability, is seen in *Scytalium Martensii*.

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The calyx in some cases affords a good character for systematic purposes. Thus the genus *Echinoptilum* is distinguished from the Veretillidae by the presence of a definite calyx with two calyx teeth. When the calyx is well developed and armed with special spicules it may show a definite and usually constant number ef calyx teeth which form a good specific character; but when there are no spicules in the calyx, as in *Virgularia*, the shape and dentation of the calyx varies so much with the degree of expansion of the anthocodia and the preservation of the specimens that its value is very greatly discounted.

The siphonozooids may be arranged on the rachis in various ways but seem to be subject to a great deal of variation in all genera. In the Pteroeididae they are confined to the leaves (p. 220) but the siphonozooid plates — as the areas are called upon which they are distributed — are variable in Pteroeides and can only be used in some cases and with some hesitation as a secondary character for the determination of species.

In the Pennatulidae, Virgulariidae and Pavonariidae there are usually siphonozooids between the leaves on the same side of the rachis and these may be arranged in one, two or several transverse rows. The total number of siphonozooids and the number of rows seem to vary, in some genera, with the number of autozooids in the leaves, and it is necessary therefore in using this character to determine these numbers in the middle of the rachis, otherwise they may be misleading.

The distribution of the siphonozooids on the dorsal track is usually a character of considerable importance but in some species their presence cannot be detected by surface examination and the statement that they are absent from the dorsal track should always be confirmed by the study of microscopic sections of the cortex of this region.

In the Veretillidae, Kophobelemnonidae, Protoptilidae and other families which do not possess leaves the arrangement of the siphonozooids is usually very irregular and does not constitute a reliable character. In *Distichoptilum* alone amongst these families there is a curious definite arrangement of two or three siphonozooids accompanying each of the widely separated autozooids. (Pl. I, fig. 7).

The presence of a verruca for the siphonozooid may be, in some cases, a character dependent upon the preservation of the specimen, but when the verruca is provided with a special arrangement of spicules as it is in some species of *Pennatula*, it may be of use as a secondary character.

Our knowledge of the distribution of mesozooids is at present so limited that their presence or absence cannot be used with confidence as a specific character. My impression is that in *Pennatula Murrayi* they constitute a good character as their number and position is constant in the 20 specimens I have examined, but in *Pennatula grandis* they seem to be more variable.

The axis affords useful characters for systematic purposes in some genera but not in others. In *Renilla*, *Echinoptilum* and *Actinoptilum* no axis has yet been found. In *Cavernularia* the axis shows extraordinary variability being sometimes present sometimes rudimentary and sometimes absent. In *Lituaria* and *Veretillum* it is usually present but probably unreliable as a specific character.

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In all the other genera of Pennatulacea it is always present. In *Pennatula*, *Pteroeides* and some other genera it seems to be always cylindrical. In full grown specimens of *Funiculina* and *Scytalium* it is always quadrangular. GRIEG (1896) has shown that in young specimens of *Funiculina* the axis is cylindrical but becomes quadrangular as it increases in size, and this will probably be found to be a general rule in the *Pennatulacea* with square axes.

In *Virgularia Rumphii* it may be either cylindrical or quadrangular and the difference between the two forms cannot be accounted for by age; the largest forms in the Siboga collection as well as some of the smallest ones having cylindrical axes the few forms with quadrangular axes being intermediate in size. In *Umbellula*, moreover, the axis shows many different shapes but a sufficient number of specimens of any one species has not yet been described to determine whether the shape of the axis in this genus is a good character for specific distinction. Specimens of *Umbellula* are still so rare and valuable that it cannot be anticipated that investigators will study the whole length of the axis of many specimens for some time to come so that it must remain a character of very doubtful value. It is probable that the structure of the axis would afford characters of considerable importance but at present our knowledge, confined to a few observations by KÖLLIKER (1865 p. 158) is insufficient to justify their use.

I have shown that the surface texture, as seen when the axis is dried, exhibits remarkable and constant differences between certain species (e. g. *Virgularia juncea* and *V. Rumphii* p. 153 and Pl. IX, figs 61—63) but in some genera (e. g. *Pteroeides*) the surface texture seems to be the same in all species.

The colour of the Pennatulacea may be due to a diffuse soluble colouring substance which is lost in preserved specimens, to an insoluble pigment in the epithelial cells or to an insoluble pigment in the calcareous substance of the spicules.

Our knowledge of the soluble pigments is very scanty as there are but few notes in the literature by naturalists who have observed the specimens when freshly caught. *Anthoptilum grandiflorum* from the Cape of Good Hope is according to the observation of Dr. GILCHRIST (HICKSON, 1904 p. 233) of a uniform bright brick red colour when alive but this colour is not retained in preserved specimens.

The insoluble pigments in the epithelial cells seem to be very irregularly distributed. They are represented by the brown spots on the rachis of *Sclerobelemnon elongatum*, the black and slaty blue patches of several species of *Pteroeides*, and the more diffuse brown colour of *Gyrophyllum*.

None of these colours however can be relied upon as characters for purposes of classification.

The bright red and yellow colours shown by many species of *Pennatula*, the purple colour of *Scytalium Balssii* (p. 208) the rose and deeper red colours of *Echinoptilum*, the red and yellow colours of *Actinoptilum* and the violet colour of *Renilla* are due to a fixed lipochrome in the spicules. These colours are very variable in nearly all the species in which they occur and can only be used as characters of secondary importance.

In *Renilla* the spicules of the rachis nearly always have a violet or amethyst colour, in *Scytalium* the spicules are always red or when seen in dense masses, purple, in *Pennatula* red and yellow colours are usually found in the spicules of the rachis, in some genera (e. g.

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Pteroeides) the spicules are always colourless. On the other hand in *Actinoptilum molle*, purple, yellow and colourless specimens may be dredged in the same locality (HICKSON 1900, *Cavernularia obesa* p. 92). Spicule colour, therefore, seems to be one of those characters which are plastic in some genera but show a tendency to become rigid in others, and its value in classification cannot be determined until a large number of specimens of any one genus or species have been examined.

Most of the Pennatulacea emit a phosphorescent light. *Pennatula phosphorea*, *Pteroeides griseum*, *Funiculina quadrangularis* and *Umbellula* have long been known to be phosphorescent. MOSELEY (1879) says that "all the Alcyonarians dredged by the Challenger in deep water were found to be brilliantly phosphorescent when brought to the surface". BROCH (1913 (1) Pl. I) gives a figure to illustrate the phosphorescence of *Umbellula Güntheri*, and according to ALCOCK (1902 (1) p. 66). *Cavernularia obesa* emits brilliant flashes of light when irritated.

The only possible exception to the general rule seems to be *Virgularia*. RUMPHIUS (1705) did not observe phosphorescence in his Sagitta marina alba which was certainly a species of *Virgularia* and HERDMAN (see HICKSON 1914 p. 473) found to his surprise that *Virgularia mirabilis* gave no sign of phosphorescence.

The histological structure of the Pennatulacea that come into the hands of the systematists is not usually sufficiently well preserved to yield reliable results. But the study of good sections frequently suggests questions that could be answered without difficulty by direct observations on living specimens or by the special preservation of certain parts of the colonies. It may not therefore be out of place to cell attention to one or two of these problems.

The external ectoderm of the Alcyonaria, unlike that of the Zoantharia is generally considered to be not ciliated. I cannot call to mind any reference in the literature dealing with the sedentary Alcyonaria in which this epithelium is said to be ciliated; but in Pennatulacea there seems to be some doubt whether the ectoderm is ciliated or not and there is no account of the distribution of ciliated tacks if any are present.

KÖLLIKER (1872 p. 424) remarks that the ectoderm cells of the Pennatulid rachis "auch Flimmerung zeigen können", and NIEDERMEYER (1913 p. 264) says that the epithelium of the rachis of *Veretillum cynomorium* "bei der das Vorhandensein von Basalkörnern u. s. w. zweifellos auf Bewimperung beim lebenden Tiere hinweist" and further "Bewimperung der Zellen ist im Stiele wohl nicht vorhanden".

From the study of some well preserved material of *Virgularia mirabilis*, for which I am indebted to the kindness of Professor HERDMAN, I am convinced that the dorsal track of this species is ciliated. But all these histological investigations lack the direct confirmation of observation of ciliary movement on the living Pennatulid.

The same may be said of the minute structure of the radial canals of *Virgularia* and the brown tubes of *Pennatula Murrayi*. The structure of the epithelium of these organs suggests very strongly that they are ciliated and it is a matter of some importance that this suggestion should be confirmed or refuted.

If they prove to be ciliated it seems probable that their main function is to assist in the circulation of water in the channels of the colony and is not excretory as was supposed at one

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time (see p. 197) but it opens up another question of wide interest and that is why they are present in some genera and not in others.

The time has not yet arrived when histological structure can play an important part in the systematics of the Order but it is to this study we must look in the future for the determination of many doubtful points in the separation of both genera and species.

THE EVOLUTION OF THE PENNATULACEA.

The Pennatulacea are so definitely marked off from other Alcyonaria by structure and habits that speculations on the possible origin and evolution of the group are of special interest.

All the Pennatulacea are free in so far as that they are not permanently attached to the bottom but capable of some movement in their holes or from place to place, the zooids of the colony are formed by budding from the body wall of the primary oozooid, never from a basal stolon, the primary oozooid which supports the other zooids of the colony develops a muscular body wall and in most of the Pennatulacea there is a structure peculiar to the group — the axis — and also a definite bilateral symmetry.

In all these characters, with one exception, the Pennatulacea are distinct from other Alcyonaria. The one exception is to be found in Telestidae where the secondary branches and zooids are formed, apparently, from the body wall of the primary oozooid.

Upon this one point of similarity BOURNE (1900 (1) p. 32) has united the Telestidae with the Pennatulacea into an order Stelechotokea.

It seems to me that the differences between the family Telestidae and the Pennatulacea far outweigh in importance the one feature of resemblance and that the Order should be kept intact. I regard the Telestidae has a highly specialised family of Alcyonacea which may have arisen independently from the Stolonifera but do not in any way represent an ancestral stage of the Pennatulacea. The gemmation from the body wall of a primary oozooid probably represents a case of convergence rather than of genetic relationship.

The most primitive form of the Pennatulacea is probably to be found in the family Veretillidae as suggested by KÜKENTHAL (1912 p. 563) and confirmed in a recent valuable paper by NIEDERMEYER (1913 p. 263).

In the Veretillidae we find *Lituaria* with solid tuberculated spicules which resemble more closely the spicules of the Alcyonacea than those of the other Pennatulacea (fig. 4, p. 19). In the same family we find *Actinoptilum* without an axis and *Cavernularia* either without an axis or with a very variable axis. In the family also we find that the muscular wall of the rachis is absent or very feebly developed. Apart from these characters which must be regarded as primitive rather than highly specialised characters the Veretillidae are also primitive in their radial symmetry.

BOURNE (1900 (1) p. 33) was of opinion that "the existing families of Pennatulacea appear to have diverged from an ancestral form resembling *Protocaulon molle*", but the difficulty of this view is that it leaves such a great gap in structure between the Pennatulacea and the other Alcyonaria. The Protocaulon stage of *Virgularia* is a complete Pennatulacean and is

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really not much nearer to *Telesto* or to any other supposed ancestral form of Alcyonacea than *Pennatula* or *Pteroeides*.

The Pennatulacea were probably derived from an Alcyonacean ancestor which prolonged its free swimming larval life until after gemmation had commenced. This necessitated a change from the primary stolonal gemmation which we find in Alcyonium (MATTHEWS 1916) to a form of gemmation from the body wall of the primary zooid. If the free swimming habit were prolonged we should expect to find 1st. the production of a radial symmetry, as in the medusae, ctenophora, pelagic radiolaria and foraminifera and other drifting organisms of the pelagic plankton, 2nd. the retention or production of dimorphism to maintain the buoyancy of the colony by the free circulation of sea water through the coelenteric cavities, 3rd. the retention of the cilia of the ectoderm.

The first of these points leads to the suggestion that the ancestor of the Pennatulacea was a free swimming colony which only later in its evolution took to the common habit of the Order of living with the stalk stuck in the mud at the bottom. There is no direct evidence that any known Pennatulacean at the present time floats or drifts about in this way but FOWLER (1894 p. 377) records that *Cavernularia malabarica* "was washed ashore in large quantities" which suggests that in this species the hold of the stalk upon the mud at the bottom is not so strong as it is in other sea pens or that the species does actually drift about freely at the bottom.

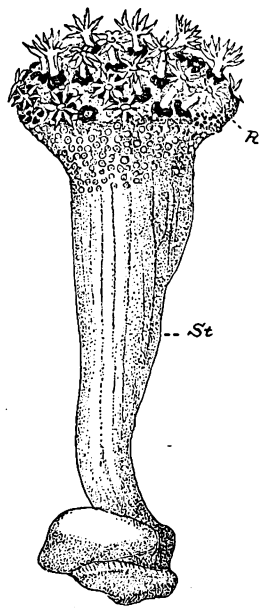

Fig. 6. *Sarcophytum trochiforme.* One of the *Alcyonacea* showing a division of the colony into a region (*R.*) corresponding with the rachis and a region (*St.*) corresponding with the stalk of the *Pennatulacea.*

But we have what seems to be a parallel case to this supposed Pennatulid ancestor in the remarkable floating Hydroid *Pelagohydra mirabilis* of New Zealand (DENDY 1902 p. 1) in which a single Hydroid zooid gives rise to stolons on its body wall from which medusae are budded and thus forms a radially symmetrical floating colony round a main axial zooid.

The second point leaves as an open question the origin of the polymorphism of the Pennatulacea. The phenomenon of dimorphism in the Alcyonaria occurs in such widely divergent forms as *Corallium*, *Paragorgia*, *Sarcophytum* and *Heteroxenia* that no hypothesis suggesting that it had a common origin could be maintained. Dimorphism must have arisen more than once in the evolution of the Alcyonaria. The Pennatulacea may have descended therefore either from a monomorphic or from a dimorphic ancestor. It seems to me however more probable that this ancestor was dimorphic as a system of siphonozooids would lend itself more readily to an increase in the duration of the free larval life.

In the species which I described as *Sarcophytum trochiforme* (1900 p. 77) since transferred to the genus Anthomastus by KÜKENTHAL (1910 (1) p. 6) we have an Alcyonacean which shows certain features of resemblance to a Veretillid. It is dimorphic, the colony shows a marked division into regions corresponding to the rachis and stalk, it is radially symmetrical and it has a very narrow base of attachment (Textfig. 6).

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These points of resemblance may be due to convergence but the species gives us a representation of what the hypothetical ancestor may have been like before it became detached and took to an independent existence.

If, then, the ancestor of the Pennatulacea was a drifting or floating colony, the axis is a structure which was not formed until a later stage of evolution when the colony acquired the habit of fixing its stalk in the mud. An axis could not be of any conceivable use to such a floating colony and would be indeed an incubus to it by forming a dead weight which would drag it to the bottom.

The entire absence of an axis shown by some of the Veretillidae is therefore, according to this conception of their evolution a primitive character. The radial symmetry in this family is also a primitive character. The thick tuberculated spicules of *Lituaria* belonging to a type such as we find in *Sarcophytum* and other Alcyonacea also represent a primitive feature in the family.

KÜKENTHAL (1912) regards the genus *Lituaria* as the most primitive of all the Pennatulacea and places it at the root of his family tree. With that conclusion I am not entirely in agreement.

Lituaria is, in my opinion the most primitive genus as regards the character of its spicules but in the possession of an axis and the occasional indications of a bilateral symmetry (p. 39 footnote) it is rather a specialised type of Veretillidae. I am inclined to believe that in spite of its modified spicular armature some species of *Cavernularia*, such as *C. malabarica*, come nearer to the ancestral form. But neither *Cavernularia* nor *Lituaria* exactly correspond with the ancestral type of the family.

The next step in the evolution of the Pennatulacea was the development of bilateral symmetry. The cause of this change is difficult to determine with our very scanty knowledge of the Natural History of the group. If it is assumed, and it is nothing but an assumption, that the sea pens can and do change their position at the bottom of the sea, and that this change of position is brought about by movements in a horizontal position along the surface of the sand or mud the origin of a surface on one side free from autozooids can obviously be accounted for.

But without any guess work assumptions, the general anatomy teaches us that the Pennatulacea with feebly developed bilateral symmetry are more closely related to the Veretillidae than those with a more pronounced bilateral symmetry.

On the one hand there is the family Kophobelemnonidae with a well developed axis and a dorsal track free from autozooids, on the other hand the Echinoptilidae with no axis and incomplete ventral track free from autozooids.

The Kophobelemnonidae are connected with the Veretillidae by *Sclerobelemnon Burgeri* a species which, in some of its varieties, can hardly be distinguished from a *Veretillum*. The Echinoptilidae are connected with the Veretillidae by the genus *Actinoptilum*.

The remarkable and isolated family Renillidae with a single genus Renilla may have been an independent offshoot from the primitive Veretillidae but there are no connecting links to indicate the possible evolution of this family.

In the family Kophobelemnonidae we find *Sclerobelemnon elongatum* to indicate the

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way in which the long and slender sea pens may have originated and *Scl. magniflorum* the way in which the autozooids may have become more and more restricted to the lateral sides of the rachis leaving the dorsal and ventral tracks free.

From this point onwards the branching of the family tree becomes too complicated to follow with any reasonable degree of accuracy. We seem to recognise a branch with the Protoptilidae near the base ending in the Chunellidae and Umbellulidae. The Pennatulacea on this branch do not develope a thick muscular wall in the rachis but show a tendency to become much more elongated and slender, to a reduction in the number of the autozooids and to the loss of spicules.

And again we see a main branch with the Anthoptilidae and Pavonariidae near the base with the Virgulariidae branching off from it in one direction and the Pennatulidae and Pteroeididae in another. In the families of this branch we see the gradual evolution of the leaves and the formation of a definite and powerful muscular body wall in the rachis.

The position of *Funiculina* in the system is obscure. I am inclined to believe that it sprang independently from the Kophobelemnoid ancestor.

The branch of the family tree with *Pennatula* and *Pteroeides* as two of its terminal twigs shows characters of special interest to the morphologist and systematist, namely the well developed bilateral symmetry of the colony and the complete system of muscles in the body wall of the primary supporting oozooid. These characters are associated with the function of movement but we are still in ignorance of the extent and rapidity of movement of nearly all the genera of Pennatulacea. We know from the observations of DARWIN (1889 p. 99) and RUMPHIUS (1705) that *Stylatula* and *Virgularia* can withdraw themselves rapidly and with force into their holes in the mud but there are no other observations upon the habits of the Pennatulacea in their natural environment. Apart from the use of the muscular system however, the structural feature is of interest because in the phylum Coelenterata it has only one parallel namely in *Cerianthus*. *Cerianthus* and the supporting zooid of the Pennatulid colony are the only examples of unattached Coelenterata with a marked bilateral symmetry and a muscular body wall. These features, moreover, they have in common with several groups of the higher Invertebrata and the Vertebrata.

To the systematist this point is of special interest also because the acquisition of the power of movement and the development of bilateral symmetry have led to the more complete differentiation of generic and in most cases specific distinctions. In the Pennatulidae, Pteroeididae and Virgulariidae both genera and species are more easily defined and show fewer connecting links than in the Veretillidae and Kophobelemnonidae.

There may still be great variability in certain plastic characters as may be seen more particularly in the genus *Pteroeides* but there is some hope, even in this genus as in the others, that when we are able to reduce the number of the so called species by the light of further knowledge, a number of well defined specific groups will remain. With the Veretillidae as with the sedentary Alcyonaria and Zoantharia increase of knowledge seems to add to our difficulties in defining both generic and specific boundaries rather than to simplify them and to lead us to the conclusion that, with certain exceptions, both recent species and recent genera overlap.

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The evolution of genera and species as they are understood in the higher animals was brought about by the evolution of bilateral symmetry and a muscular body wall and these structural features were the result of the acquirement of independent movement in a definite direction.

GEOGRAPHICAL DISTRIBUTION.

The waters of the Malay archipelago evidently support a very rich fauna of Pennatulacea. Specimens of this Order were obtained by the Siboga expedition at 59 stations and these have been found to include representatives of 17 of the 32 recognised genera. The total number of specimens was about 550.

The great variety of the collection is however not fairly expressed by the bald statement that seventeen out of the thirty two recognised genera of the Pennatulacea are represented for of the fifteen genera not in the collection at least seven are of doubtful value and may be suppressed when they are better known. It may be better expressed by saying that all the well known genera are represented in the collection except: — *Actinoptilum*, *Renilla*, *Pavonaria*, *Stylatula*, *Leioptilum*, *Acanthoptilum* and *Sarcophyllum*.

Of the seventeen genera represented in the collection the following eleven have not been previously recorded from the Archipelago: *Anthoptilum*, *Chunella*, *Distichoptilum*, *Echinoptilum*, *Gyrophyllum*, *Protoptilum*, *Sclerobelemnon*, *Scytalium*, *Umbellula*, *Veretillum* and the genus *Kophobelemnon* has only once been previously recorded from the West coast of Sumatra. The genus *Stachyptilum*, first described by KÖLLIKER (1880 p. 11) from the Challenger station S. E. of Ceram, is not represented in the Siboga collection.

Of special interest from the point of view of geographical distribution is the occurrence of *Chunella gracillima* previously recorded only from the E. coast of Africa, of the genus *Gyrophyllum* previously recorded only from the N. Atlantic ocean and of five species of the genus *Umbellula* (see p. 125 genus *Crinillum*). These are all deep sea forms and may have a cosmopolitan but interrupted distribution in the abysmal depths of the oceans but the remarkable resemblance of the specimens of *Chunella gracillima* from the Malay Archipelago and from the E. coast of Africa and of the rare genus *Gyrophyllum* from the Malay Archipelago and from the N. Atlantic ocean forms one of the most noteworthy features of the collection.

Special attention may be called to the fact that the *Gyrophyllum* from the Malay archipelago was found in much shallower water (567 metres) than the specimens from the Atlantic ocean (1266—2200 metres) and similarly that the specimens of *Umbellula durissima* were found in much shallower water (567 metres) than those from other localities (1000—3000 metres).

It cannot be supposed, for a moment, that even this splendid collection is exhaustive and it may be anticipated that the genus *Sarcophyllum* so prevalent in Australian and New Zealand waters and perhaps other genera as well will be found to extend into the Malayan area.

Our knowledge of the Pennatulacean fauna of the world is still so imperfect that it is perhaps premature to suggest affinities and base conclusions upon them; but, so far as our

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knowledge goes, the fauna of sea-pens in the Malay archipelago exhibits features of the Western Pacific ocean combined with those of the Indian Ocean. The genera *Lituaria*, *Cavernularia*, *Echinoptilum*, *Sclerobelemnon*, *Scytalium* and the species *Pennatula Murrayi* occur in both these areas as well as in the Malay Archipelago.

Veretillum (Policella), *Anthoptilum*, *Protoptilum*, *Distichoptilum* and *Chunella gracillima* occur in the Indian Ocean but not in the Western Pacific. Such characteristic species as *Pennatula fimbriata* and *P. Naresi* occur in the Western Pacific but not in the Indian Ocean.

The Australian and New Zealand fauna is represented by the genera *Lituaria*, *Veretillum (Policella)* and by the species *Virgularia gracillima*. The Atlantic fauna is represented by the genus *Gyrophyllum*.

In the Malayan waters moreover all the widely distributed genera are represented, such as *Veretillum*, *Kophobelemnon*, *Funiculina* (?), *Umbellula*, *Virgularia*, *Pennatula* and *Pteroeides* and the last three of these occur in great numbers and varieties. Specimens of *Virgularia* were obtained at nineteen stations, of *Pennatula* at nine stations and of *Pteroeides* at twelve stations.

The study of the specimens of *Pteroeides* collected by the Siboga expedition from Malayan waters together with the records of species obtained in this region by previous expeditions (see p. 234) suggests that they are the head quarters of the world for this genus.

Even if the tendency shown by many authors to multiply species unwarrantably is discounted the fact that no less than 18 specific names have been given to specimens of *Pteroeides* collected in the Malay Archipelago alone is eloquent testimony of the great variety of form the genus presents.

A similar remark may be made about the genus *Virgularia*. We seem to find in this single area nearly all the principal varieties of form — whether they are true species or not — that the genus presents. There is the "Halisceptrum" form with large leaves, the "Juncea" form with short leaves composed of many autozooids, the "Svavopsis" form with the autozooids arranged in tufts on the leaves, the slender "Gracillima" form with very small leaves and others. The Malayan waters seem therefore to be also the headquarters of the genus *Virgularia*.

As regards other genera we have not at present a sufficient number of specimens to justify a similar conclusion but the facts as they stand are quite in accordance with the theory that the Malay Archipelago is or has been a distributing centre of the Pennatulacea of the world.

Of the genus *Echinoptilum* for example two species were known, one (*E. M'Intoshii*) from Japan and one (*E. echinatum*) from the East coast of Africa.

The four species of the genus described in this monograph from the Malay Archipelago connect the other two outlying species. Specimens of the same genus are also described by NUTTING (1908 p. 561) from the Hawaian islands but the description is not sufficiently exact to enable me to determine with certainty whether they are correctly assigned to the species *E. M'Intoshii*.

The distribution of this genus therefore might be represented by a figure with a centre in the Malay Archipelago and three rays, one pointing to the North, one to the East and one to the West.

For the genus *Scytalium* the figure would have two of these rays the one pointing North

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and the other pointing West. The well defined species of the genus Pennatula, *P. Murrayi*, has a similar distribution to that of the genus *Scytalium*.

The Kophobelemnonidae are well represented in this central area by several species of the more primitive genus *Sclerobelemnon* and by one species, from several stations in the area, of *Kophobelemnon*. The genus *Sclerobelemnon* extends north from this centre to Formosa and west as far as the Red Sea. *Kophobelemnon* has spread north as far as Hong Kong, east to the coast of central America, west into the Indian and Atlantic Ocean and, if we may judge from the capture by the Challenger expedition of a single specimen off N. New Zealand, also to the South. It has, in fact become a cosmopolitan genus. If we consider the distribution of the characteristically deep sea genus *Umbellula* no reason is found to doubt this general conclusion as to the distribution of the Pennatulacea. It is generally agreed that the fauna of the deep sea has been derived from the shallow water fauna and it is clear from the evidence obtained from the many deep sea dredging expeditions that the genera and species of the deep sea fauna, in the absence of geographical barriers, show a stronger tendency to become cosmopolitan in distribution than the species of the shallow water.

Umbellula is such a genus originally derived from the shallow waters of some unknown region, and now distributed in deep or very deep water over the floor of all the great ocean basins.

We might expect to find, in the neighbourhood of this unknown region, representatives of the principal varieties of the genus living in comparatively shallow water. This is exactly what we do find in the Malay Archipelago where four species have been found ranging in depth from 310 to 1158 metres. The occurrence of specimens of *Umbellula Huxleyi* in 296 metres off the Great Nicobar, of *U. pendula* in 230—400 metres off the Andaman islands and of several species in comparatively shallow water in the Arctic Ocean does not in my opinion offer insuperable difficulties to the suggestion that the Malay Archipelago was the centre of distribution of the genus, as the fauna of the Eastern Indian Ocean is practically continuous with that of the Malay Archipelago and the occurrence of the genus in cold water in the North may be accounted for in other ways.

The occurrence of *Chunella gracillima* in deep water off the East coast of Africa and in the Malay Archipelago, standing by itself, is a mysterious fact of distribution but *Chunella biflora*, described in this monograph, provides us with a connecting link between *Chunella* and NUTTING's genus *Calibelemnon* — now merged with Chunella — and at the same time a species occupying an intermediate position in depth between *C. gracillima* and the species hitherto attributed to *Calibelemnon*.

The evidence is most conclusive that the very remarkable deep sea Pennatulid, originally described by KÜKENTHAL (1902 (1) p. 302) *Chunella gracillima* (Pl. III, fig. 15) is derived from a shallow water species similar to *Chunella* (*Calibelemnon*) *indicum* of THOMSON and HENDERSON from 100 metres in the Indian Ocean, and that many of the stages of its evolution are preserved for us in the recent fauna of the waters of the Malay Archipelago.

Another feature we might expect to find in the fauna of a locality which is supposed to be the centre of distribution of an Order we also find in the Malay Archipelago. I refer to the preservation of the primitive genera and species.

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KÜKENTHAL originally suggested, contrary to the prevalent opinion at the time, that we find in the Veretillidae the most primitive representatives of recent Pennatulacea. With that suggestion I am in full agreement. This family is represented in the Archipelago by the three genera *Lituaria*, *Veretillum* and *Cavernularia*.

It is true that there are not many species nor many specimens of them in the collection made by the Siboga expedition but I believe it will be found that they have a wider distribution in the area than the facts at our command indicate. Branching off from the Veretillidae came on the one hand the genus *Echinoptilum* and on the other the genus *Sclerobelemnon*. Both of these are represented by several very interesting species. The Sclerobelemons are of special importance in this respect on account of their extreme variability, and the genus seems to be in the act of splitting up into a large number of incipient species, some of them already well defined, others merging into one another and into the genus *Veretillum* from which they were derived.

Some authors have regarded the Protocaulon-Deutocaulon type of structure as the ancestral form of the Pennatulacea. With that view I am not in agreement. But if JUNGERSEN is right in believing that the type specimens of Protocaulon and Deutocaulon are young stages in the development of the colony of a *Virgularia* — and the evidence all points in favour of JUNGERSEN's view — it is quite reasonable to suppose that the ancestral form of the leaf forming Pennatulacea may have had a structure resembling in some general respects these stages in the development of *Virgularia*. Such a form we find in the smaller specimens of the Malayan *Chunella biflora* (Pl. I, fig. 2) as well as in the Protocaulon and Deutocaulon stages of the species of *Virgularia*.

The interesting collection of specimens of *Scytalium* from the Malay Archipelago may be regarded as having a similar significance.

This family was formerly classified with the Virgulariidae but in this memoir is treated as a member of the family Pennatulidae.

Whatever its true position may be there can be little doubt that it is a less highly specialised form than *Pennatula* and represents an earlier offshoot from the line of descent of that genus. It is of special interest therefore to note that in this region the three principal forms that the genus presents namely the extremely slender form with very small leaves represented by *Sc. Martensii* the stouter form with larger leaves represented by *Sc. Sarsii* and the short stout form with very large leaves represented by *Sc. Balssii*, occur.

All these facts are consistent with the statement made at the beginning of this chapter that the Malay Archipelago may be regarded as the headquarters of the Pennatulacea and the absence — or apparent absence, for our knowledge of this district is not yet complete — of such genera as *Sarcophyllum* of the Australian region, *Renilla* of the coasts of the American continent, *Stylatula* of the North Atlantic and *Pavonaria* of the North Atlantic and North Pacific Oceans does not seriously undermine this general conception.

In the discussion of the geographical distribution of these animals KÜKENTHAL and BROCH (1911 p. 466), make the following statement:

"Nur ganz allgemein lässt sich sagen, dass die ganz ausserordentlich starke Anhäufung

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von Fundorten verschiedener Arten und Gattungen an der Küste Indiens dafür spricht, dass hier die Entwicklung des Pennatulidenstammes vorwiegend vor sich gegangen sein mag".

It is not quite clear to me what the German authors intended to include in the rather vague expression "the coasts of India" but if we substitute for it "the waters of the Malay Archipelago" the sentence just quoted would completely express my own views.

The richness of this region in Pennatulacea is equalled or excelled by its richness in other groups of marine animals. Several of the authors of the monographs in this series have commented on the great variety of the genera and species of the portions of the collections they have examined. MAX WEBER for example speaks of the Malay region as one of the richest in the world, for marine fishes. ALCOCK (1902 (2) p. 3) in writing on the Madreporaria says "The Southern end of the Sulu sea seems to be one of the richest places in the world for deep sea corals" and "hardly less fertile is the neighbourhood of the Kei islands and Banda sea". "The basins explored by the "Siboga" are vastly richer in species than the depths of the seas of the West part of the oriental region explored by the "Investigator".

From another source I may quote the remark of CLARK (1912 p. 9) that the Crinoidea show "a maximum intensity within a triangle whose apices are Luzon, Borneo and New Guinea in which 18 of the 19 families and 71 of the 82 genera are known to occur".

The evidence that I have brought forward, therefore, as regards the single group of the Pennatulacea, that the fauna of the Malay region is extraordinarily rich, is confirmed by the evidence derived from the study of other groups of animals and everything points to the conclusion that the contribution to our knowledge of marine zoology made by the results of the memorable Siboga Expedition will prove to be of the highest possible interest and importance.

LIST OF GENERIC SYNONYMS.

As the names of many genera that have been used in the recent literature of the Pennatulacea have disappeared from the system used in this monograph I have given in the following lists, for the convenience of systematists, a list of the submerged genera showing the genera with which they have been amalgamated and the page in the text to which reference may be made for the reasons given for their submergence.

			page
Amphiacme	=	*Chunella*	108
Amphianthus	=	*Chunella*	108
Argentella	=	*Pteroeides*	219
Bathyptilum	=	*Kophobelemnon*	70
Benthoptilum	=	*Anthoptilum*	140
Calibelemnon	=	*Chunella*	108
Cavernulina	=	*Cavernularia*	54
Cladiscus	=	*Virgularia*	155
Clavella	=	*Lituaria*	42
Crispella	=	*Pteroeides*	219
Deutocaulon	=	*Virgularia*	90
Dübenia	=	*Stylatula*	147
Fusticularia	=	*Cavernularia*	40
Godeffroyia	=	*Pteroeides*	219
Göndul	=	*Pavonaria*	135
Gunneria	=	*Kophobelemnon*	70
Halipteris	=	*Pavonaria*	146
Halisceptrum	=	*Virgularia*	155

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		page
Juncoptilum	= *Distichoptilum*	96
Leptoptilum	= *Funiculina*	96
Lygomorpha	= *Pavonaria*	96
Lygus	= *Virgularia*	156
Mesobelemnon	= *Sclerobelemnon*	79
Microptilum	= *Pavonaria*	96
Norticina	= *Pavonaria*	135
Phosphorella	= *Pennatula*	181
Policella	= *Veretillum*	46
Prochunella	= *Chunella*	110
Protocaulon	= *Virgularia*	96
	= *Chunella*	116
Pteromorpha	= *Pteroeides*	219
Ptilella	= *Pennatula*	181
Ptilosarcus	= *Leioptilum*	188
Sarcobelemnon	= *Cavernularia*	50
Sarcoptilus	= *Leioptilum*	188
Scytaliopsis	= *Virgularia*	159
Stichoptilum	= *Pavonaria*	96
Struthiopteron	= *Pteroeides*	219
Stylobelemnon	= *Cavernularia*	50
Svava	= *Virgularia*	156
Svavopsis	= *Virgularia*	169
Thesioides	= *Anthoptilum*	142
Trichoptilum	= *Funiculina*	96
Verrillia	= *Osteocella*	136

LIST OF SPECIES

collected by the Siboga expedition.

FAMILY, GENUS AND SPECIES.	STATION.	DEPTH IN M.	LOCALITY.	NUMBER OF SPECIMENS.
Family VERETILLIDAE.				
Genus **Lituaria.**				
Lituaria Hicksonii Thomson & Simpson	51	69—91	Molo Strait	1
" " " "	240	9—45	Banda Reef.	1
Genus **Veretillum.**				
Veretillum tenue Marshall & Fowler . .	213	—36	Saleyer Reef	1
Veretillum malayense n. sp.	47	55	Bay of Bima	3
Genus **Cavernularia.**				
Cavernularia orientalis Thoms. & Simps.	181	36—54	Amboyna	4
Family ECHINOPTILIDAE.				
Genus **Echinoptilum.**				
Echinoptilum asperum n. sp.	85	724	W. coast Celebes	2
" " "	178	835	" " Ceram	1
Echinoptilum elongatum n. sp.	318	88	Ketapang Bay, Kangeang I.	4
Echinoptilum minimum n. sp.	299	73	S. coast Timor	40
Echinoptilum roseum n. sp.	251	204	off Kei Islands	1
Family KOPHOBELEMNONIDAE.				
Genus **Kophobelemnon.**				
Kophobelemnon pauciflorum n. sp.	5	330	Bali Sea	1 Juv.
" " "	85	724	W. Celebes	1

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FAMILY, GENUS AND SPECIES.	STATION.	DEPTH IN M.	LOCALITY.	NUMBER OF SPECIMENS.
Kophobelemnon pauciflorum n. sp.	137	472	near Halmaheira	22 + 1 Juv.
" " "	271	1788	Aru Islands	4
" " "	300	918	Rotti	1
Genus **Sclerobelemnon.**				
Sclerobelemnon Burgeri Herklots	49a	69	Sapeh Strait	1
" " "	51	69—91	Molo "	58
" " "	51x	—	" "	4
" " "	51y	—	" "	1
" " "	193	22	off Sanana Bay, Sula Besi	1
" " "	258	22	Tual, Kei Island	1
" " "	294	73	off Timor	1
Sclerobelemnon elongatum n. sp.	181	36—54	Amboyna	30
" " "	320	82	Java Sea	1
Sclerobelemnon Gravieri n. sp.	51	69—91	Madura Bay	6
" " "	294	73	off Timor	9
Sclerobelemnon magniflorum n. sp. . . .	137	472	off Halmaheira	2
Family PROTOPTILIDAE.				
Genus **Protoptilum.**				
Protoptilum celebense n. sp.	87	655	Palos Bay, Celebes	1
" " "	208	1886	Buton Strait	1
" " "	212	462	West of Saleyer	1
Genus **Distichoptilum.**				
Distichoptilum gracile Verrill	35	1310	Bali Sea	1
" " "	45	794	Paternoster Islands	3
" " "	85	724	off W. Celebes	1
" " "	122	1264—1165	N. Celebes	1
" " "	271	1788	off Aru Islands	2
Family CHUNELLIDAE.				
Genus **Chunella.**				
Chunella biflora n. sp.	167	95	off Buton	1
" " "	204	75—94	" "	1
" " "	302	216	off Rotti Islands	13
Chunella gracillima Kükenthal	18	1018	Bali Sea	2
Family UMBELLULIDAE.				
Genus **Umbellula.**				
Umbellula antarctica Kükenthal	17	1060	near Java	1
" " "	211	1158	" Saleyer	1
" " "	254	310	" Kei Islands	1
Funiculina?	18	1018	Bali Sea	1

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FAMILY, GENUS AND SPECIES.	STATION.	DEPTH IN M.	LOCALITY.	NUMBER OF SPECIMENS.
Umbellula durissima Kölliker	173	567	near Ceram	2
Umbellula Jordani Nutting	211	1158	off S. Celebes	1
Umbellula pellucida Kükenthal.	300	918	near Rotti	2
Umbellula Weberi n. sp.	18	1018	„ Bali	1
Family ANTHOPTILIDAE.				
Genus **Anthoptilum.**				
Anthoptilum malayense n. sp.	52	959	S. of Flores Island	2
Family VIRGULARIIDAE.				
Genus **Virgularia.**				
Virgularia gracillima Kölliker	71	—32	Makassar	1 fragt.
„ „ „	77	59	Borneo Bank	1
„ „ „	181	36—54	Amboyna	4 fragts.
„ „ „	206	51	Buton Strait	7
„ „ „	285	34	Timor	1 young
„ „ „	321	82	off Madura	16
Virgularia Gustaviana Herklots	181	36—54	Amboyna	3
Virgularia juncea Pallas	163	29	Seget Reef, N. Guinea	2
„ „ „	174	18	Waru „ Ceram	4
„ „ „	213	—36	Saleyer	34
„ „ „	272	31	Aru	2
Virgularia Roulei n. sp.	99	16—23	N. Ubian	1 fragt.
„ „ „	133	—36	off Lirung, Talaut Islands	2 „
„ „ „	181	36—54	Amboyna	1
„ „ „	240	9—45	Banda	1 fragt.
Virgularia rubra n. sp.	181	36—54	Amboyna	Several fragts.
„ „ „	240	9—45	Banda	3 fragts.
Virgularia Rumphii Kölliker	51	69—91	Molo Strait	1 „
„ „ „	99	16—23	Sulu Archipelago	1 „
„ „ „	115	Reef	Kwandang Bay, Reef	1 „
„ „ „	121	55	Menado Anchorage	15
„ „ ? „	142	23	Obi	8 fragts.
„ „ „	174	18	N. coast Ceram	1 „
„ „ „	258	22	Tual, Kei Islands	9 „
Virgularia sp.?	51	69—91	Molo Strait	5
„ „	77	59	Borneo Bank	1
„ „	294	73	off Timor	1
Family PENNATULIDAE.				
Genus **Pennatula.**				
Pennatula fimbriata Herklots	251	204	near Kur Island	1
„ „ „	256	397	Kei Islands	1
„ „ „	289	112	S. coast Timor	3
Pennatula indica Thoms. & Henderson.	221	2798	Banda Sea	2
Pennatula Murrayi Kölliker	167	95	Misool Island	1 Juv.
„ „ „	254	310	Kei Islands	2

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FAMILY, GENUS AND SPECIES.	STATION.	DEPTH IN M.	LOCALITY.	NUMBER OF SPECIMENS.
Pennatula Murrayi Kölliker	256	397	Kei Islands	3
" " "	260	90	" "	1 Juv.
" " "	289	112	Coast of Timor	7
Pennatula Naresi Kölliker	45	794	near Postillon Islands	4
Pennatula sp.?	251	204	Kei Islands	1
" "	284	828	S. off Timor	6
Genus **Scytalium.**				
Scytalium Balssii n. sp.	282	27—54	near Timor	3
Scytalium Martensii Kölliker	289	112	off S. coast Timor	100
" " "	260	90	Kei Islands	1
Scytalium Sarsii Herklots	71	—32	Makassar	1
" " "	318	88	Java Sea	1
" " "	319	82	" "	1 broken
Scytalium sp.?	1	37	Madura Strait	1 small
" "	49a	69	Sapeh Strait	2 and
" "	105	275	Sulu Archipelago	1 broken
" "	204	75—94	off Buton	1 specimens
Family PTEROEIDIDAE.				
Genus **Pteroeides.**				
Pteroeides argenteum Kölliker			N. Guin. Exp. 1903 Humboldt Bay.	2
Pteroeides caledonicum Kölliker	181	36—54	Amboyna	3 also 1 incert.
" " ? "	37	—27	Paternoster Islands	1 Juv.
Pteroeides malayense n. sp.	79	41—54	E. Borneo Bank	9
" " "	79a	54	" " "	5
" " "	133	—36	off Lirung, Salibabu I.	1 (imperfect)
" " "	240	9—45	Banda	1
" " "	Loc. incert.			1
Pteroeides nigrum Kölliker.	231	40	Amboyna	1
Pteroeides speciosum Kölliker.	51	69—91	Molo Strait	1 (imperfect)
" " "	117	80	Kwandang Bay	1 Juv.
Pteroeides timorense n. sp.	299	73	S. coast Timor	1
Pteroeides sagamiense? (Moroff)	240	9—36	Banda	1 Juv.
Pteroeides chinense? Kölliker.	164	32	W. of N. Guinea	1 Juv.
Genus **Gyrophyllum.**				
Gyrophyllum Sibogae n. sp.	173	567	near Ceram	1

In addition to the species described in the text I have also studied for purposes of comparison the following species in the collection of the Manchester Museum and in other collections that have passed through my hands.

Lituaria phalloides	from	Mergui.
Veretillum cynomorium	"	Mediterranean.
Cavernularia obesa	"	Andaman Islands.
Actinoptilum molle	"	Cape of Good Hope.
Renilla reniformis	"	Beaufort. America.

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Kophobelemnon stelliferum	from	Mediterranean.
Funiculina quadrangularis	„	W. coast of Scotland.
Umbellula Carpenteri	„	Antarctic.
Umbellula aciculifera	„	Cape of Good Hope
Osteocella septentrionalis	„	British Columbia.
Anthoptilum grandiflorum	„	Cape of Good Hope
Anthoptilum Kükenthali	„	Indian Ocean.
Virgularia mirabilis	„	W. coast of Scotland.
Virgularia Schultzei	„	Cape of Good Hope
Pennatula phosphorea	„	Several locs.
Pennatula grandis	„	Faeroe channel.
Leioptilum sinuosum	„	California.
Pteroeides (several species).		
Sarcophyllum grande	„	Australia.
Gyrophyllum hirondellei	„	Atlantic.

Family Veretillidae.

Veretillidae ex parte. Kölliker. 1872. Die Pennatuliden. p. 370.
Veretillidae Kükenthal and Broch. 1911. "Valdivia" Pennatulacea. p. 168.

The name Veretillidae was used by Kölliker (1872) for a "Company" (Zunft) which included two families; the Kophobelemnonieae and the Veretilleae. The name was used by Kükenthal and Broch (1911) for a family from which the genera *Kophobelemnon* and *Sclerobelemnon* were excluded.

In this memoir the family Veretillidae is taken to include the same genera as those in the system of Kükenthal and Broch with the addition of the genus *Actinoptilum* which was referred by them to the family Echinoptilidae.

Of the five genera of Veretillidae recognised by Kükenthal and Broch two disappear from our system, *Cavernulina* being merged with *Cavernularia* and *Policella* with *Veretillum*.

The genera included in the family therefore are: —

Lituaria Valenciennes (1850).
Veretillum Cuvier (1798).
Cavernularia Valenciennes (date?).
Actinoptilum Kükenthal (1910).

To these four well established genera may he added two more which seem to occupy an intermediate position between *Cavernularia* & *Actinoptilum*; namely *Parabelemnon* Thomson and Simpson (1909 p. 307) and *Stylobelemnoides* Thomson and Henderson (1905 (1) p. 325).

The family Veretillidae includes all those Pennatulacea in which the zooids are evenly distributed on all sides of the rachis and in which there are no external signs of bilaterality.

The Veretillidae are all stout club shaped or cylindrical sea-pens in which the autozooids

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and siphonozooids are distributed without any definite arrangement in horizontal or longitudinal rows all round the rachis. There is never any track free from these zooids on either the dorsal or ventral sides so that there is no external evidence of bilaterality [1]).

The only difficulty in accepting this as the definition of the family is that in some specimens of *Sclerobelemnon Burgeri* there is also no track on the rachis that is free from autozooids. Having had the opportunity of examining a large number of specimens of this species I can assert that this difficulty arises in only a small number of cases but the species is undoubtedly, in this respect and in others, a connecting link between the Veretillidae and the Kophobelemnonidae.

Apart from this one character the Veretillidae show so much variation that it is impossible to add to the definition without making it unduly long.

The spicules may be solid double clubs or "capstans", spheres or ovals, flat plates or rods, minute otolith-like corpuscles or absent altogether. The axis may extend the whole length of the colony as in other Pennatulacea, it may be short and attenuated or absent. The autozooids vary a good deal in size and in their power of retraction but neither of these characters nor their arrangement on the rachis afford satisfactory means for making generic distinctions.

With this extreme variability in all the characters on which the systematic arrangement of the Sea-pens usually depend, it is a matter worthy of deep consideration whether we are justified in dividing the family into generic groups at all. The more we learn about the detailed structure of the Veretillidae and the many varieties that are found in different districts of the world the more uncertain becomes the basis of our classification and it seems very probable that before many years have passed the four genera now recognised will be merged iuto one genus with the characters of the family.

Already several of the older generic names such as *Clavella*, *Policella* and *Stylobelemnon* have been suppressed and the separation of the other genera, it must be admitted, is unsatisfactory.

In his scheme of classification of the family Veretilleae KÖLLIKER (1872 p. 295) made great use of the axis as a distinctive character grouping the species according to their possession of a long axis, a short axis or no axis at all. As shown originally by BALSS (1910 p. 83) however, the axis is not a good character upon which to base a generic distinction as it is a character which is very variable even within the range of a single species. It may be added, that it is also a very inconvenient character on which to determine genera as it cannot be thoroughly examined without considerable damage to the specimens.

The spicular armature is also very variable and may prove to be as unreliable as the axis but if we are to retain any generic distinctions at all in the family it is to the spicules we must look for the necessary characters.

The scheme that I suggest is one based on certain general considerations concerning the evolution of the Order and consists in an attempt to arrange these genera in an order that may represent their genetic relationship.

KÜKENTHAL (1912 p. 563 etc.) in several of his writings, has given reasons for believing

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1) MARSHALL & FOWLER (1887 p. 282) and later FOWLER (1894 p. 377) state that a plane of bilateral symmetry is indicated in *Lituaria phalloides*.

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that, contrary to the general opinion, the radially symmetrical Veretillidae are the most primitive of the Pennatulacea, and his views are supported by the more recent investigations of NIEDERMEYER (1913, p. 263). With the opinion that we find in the family Veretillidae some of the most primitive characters in the order I am in agreement and further that to the Alcyonacea rather than to the Telestidae we most look for the origin of the group (p. 25). If we assume that the Alcyonacea gave rise to the Pennatulacea we might expect to find in the Veretillidae a type of spicule that is prevalent in the Alcyonacea.

Such a type of spicule we find in the "double club", or "capstan" that is to say the solid double-head spicule with dentate processes scattered over the two extremities (fig. 4 p. 19).

From this type of spicule, evolution may have proceeded in two directions.

1st. In the direction of a flattening of the spicule until it became a thin plate with jagged edges arranged tangentially in the cortex of the rachis and finally a smooth round or oval plate or disc. This type of evolution we can trace in *Lituaria*, *Veretillum* and *Sclerobelemnon* (Fig. 8 p. 49 and fig. 18 p. 84).

2nd. In the direction of becoming a branched and afterwards an unbranched elongated smooth needle such as we find in the species of the genus *Cavernularia* (Fig. 9 p. 53).

The thin plate form of spicular armature does not appear to have been very successful as it is confined to the genera which we regard as the most primitive genera of the Order, is always very variable and frequently degenerates altogether (c. f. *Veretillum manillense* etc.).

The needle-shaped type of spicular armature on the other hand which shows itself first in some of the species of *Cavernularia* is carried on into the other families of the Pennatulacea and eventually becomes the well known long, ridged (dreiflügelig) (Fig. 5 p. 19 etc) or 3-flanged needle so characteristic of some of the higher genera of the Order.

The four, principal genera of the Veretillidae may be arranged then in the following Order: —

Lituaria, with thick double-club or dumb-bell shaped thorny spicules.
Veretillum, with thin plate-like spicules very variable in number and in outline.
Cavernularia with smooth rod or needle-shaped spicules, branching at the extremities in some species. Without verrucae.
Actinoptilum with rod-shaped ridged spicules. With verrucae.

In addition to the genera referred to above three generic names have recently been given to specimens that should probably be included in the Veretillidae.

Fusticularia, SIMPSON (1905 p. 561) cannot be clearly separated from *Cavernularia* and it seems to be an interesting young stage of one of the species of that genus.

Parabelemnon of THOMSON and SIMPSON (1909 p. 307) is a Veretillid with a well developed axis and autozooids that are protected at their bases by "bird-nest-like" verrucae. KÜKENTHAL and BROCH (1911 p. 171) consider that these verrucae may be retractile and not therefore strictly comparable with the calices of *Actinoptilum*. This does not seem to me probable in view of the statement that "The Polyps are completely retractile within fairly definite verrucae formed by the longitudinally disposed spicules arranged in four groups which terminate in four triangular points".

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The spicules appear to be very variable in shape but resemble in some respects the spicules of *Cavernularia orientalis.*

The genus seems to me to form a connecting link between *Cavernularia* and *Actinoptilum* resembling the former in its spicules and the latter in its verrucae but it differs from both in its well developed axis.

Stylobelemnoides of THOMSON and HENDERSON (1905 (1) p. 325) is also an intermediate form between these two species but the "calices" have "eight double rows of spicules" and the axis is cylindrical [1]).

The account that is given of these two genera from the Indian Ocean, connecting *Cavernularia* with *Actinoptilum* appears to me to render it absolutely necessary to include *Actinoptilum* in the same family with *Cavernularia.* To separate *Actinoptilum* as is done by KÜKENTHAL and BROCH, and place it in another family (Echinoptilidae) suggests a discontinuity which does not exist.

Actinoptilum is unquestionably closely related to *Cavernularia.* The specimens I described as *Cavernularia obesa* and *C. elegans* from the CAPE (1900) are undoubtedly, as KÜKENTHAL and BROCH have pointed out the same as their species *Actinoptilum molle.*

A further series of specimens from the CAPE that have been described by Dr. STUART THOMSON (1915) supply the connecting links between the types described as *C. elegans* and *C. obesa*, and between these types and those described by KÜKENTHAL and BROCH.

The presence of non-retractile verrucae supported by a fan-shaped arrangement of the spicules seems to be a constant feature of the genus, in which it agrees with *Parabelemnon* & *Stylobelemnoides* but differs from *Cavernularia.*

Another point of difference between *Actinoptilum* and *Cavernularia* appears to be that the spicules of the rachis of the former are ridged whereas in the latter they are usually smooth. But the elongate needle-shape of the spicules is similar in *Actinoptilum* to that in some species of *Cavernularia*, the texture of the rachis and the arrangement of the zooids in the two genera cannot be distinguished and *Parabelemnon* with the smooth branched spicules and more rudimentary verrucae forms a connecting link between them.

Although the genus *Echinoptilum* is in this memoir regarded as the type of a distinct family, its affinities are undoubtedly with the Veretillidae. The calyx of *Echinoptilum* is undoubtedly a true calyx formed by the body wall of the autozooid. In *Actinoptilum* the structure called the "calyx" is much more variable and, in all the specimens I have examined, appears to arise from the part of the rachis surrounding the base of insertion of the autozooid and not from the body wall of the autozooid itself. It is, in my opinion, not a true calyx but a verruca. In the figure of *Actinoptilum molle* given by KÜKENTHAL and BROCH (1911 Pl. XIII figs 3 and 4) these verrucae are not well shown and in the well preserved fully expanded specimens from the Cape of Good Hope they are little more than collars at the base of the autozooids. In the contracted specimens they are much more prominent owing to the folding of the wall of the rachis over the aperture for the autozooid when the anthocodia is retracted.

1) There are contradictory statements in the original description but as the axis is described as cylindrical twice and square once, it is probably cylindrical.

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It is possible that in some cases the base of the body wall of the anthocodia may be thickened and take part in the formation of the verruca. There are doubtless intermediate conditions between our conception of a calyx and of a verruca but on comparing the many specimens of *Actinoptilum* at my disposal with those of *Echinoptilum* I am convinced that in the former genus these structure are more correctly named "verrucae" and in the latter "calices".

The pronounced bilateral symmetry which all the specimens of *Echinoptilum* exhibit is another character which justifies the separation but as there are indications of a bilateral symmetry in some specimens of *Actinoptilum* (THOMSON 1914 p. 7) and of *Lituaria* (FOWLER 1894 p. 377) it is not a feature that absolutely divides the families.

Genus **Lituaria.**

Lituaria Valenciennes. British Fossil Corals 1850. Introduction.
Clavella Gray. Catalogue of Sea-pens 1870 p. 33.
Lituaria + *Clavella*. Kölliker. Die Pennatuliden. 1872 pp. 213 & 322,
Lituaria Marshall and Fowler. Pennatulida of Mergui 1887 p. 282.
Lituaria Balss. Japanische Pennatuliden 1910 p. 81.

The genus was founded by VALENCIENNES for the Pennatulid described by Pallas (1766 p. 210) under the name *Pennatula phalloides*. In the german edition of PALLAS' work, Wilkens states that the species is found in East Indian seas off the Coast of Amboyna. The figure he gives is not very much like either of the specimens in the Siboga collection, as it shows a definite constriction at the base of the rachis and a very long stalk.

It may be a matter of some doubt whether the *Lituaria* of VALENCIENNES is the same thing as the *Lituaria* of KÖLLIKER and subsequent authors but as it is, in my opinion, convenient to keep a separate generic name for the *Lituaria phalloides* described by KÖLLIKER and the *Lituaria Hicksoni* of THOMSON and SIMPSON, the name will be retained.

KÖLLIKER (1872) recognised only one species *L. phalloides* and he gives the distribution of this species as Amboyna, Sumatra and Penang. He described a specimen 127 mm. in length but does not state from which of these localities the specimen was taken. In contrast to PALLAS who speaks of the rachis as "cylindrical" he calls the colony club-shaped ("Stock keulenförmig").

In the description of the genus he gives the following description of the spicules. "Kalkörper von der Gestalt biskuitförmiger unregelmässig mit Stacheln besetzter Platten".

From this it might be supposed that the spicules are all flat or thin plates but in the further description of these bodies on page 315 he adds "dass ihre Flächen und Enden ganz unregelmässig mit mehr weniger zahlreichen Warzen und Stacheln besetzt sind". The figure moreover that he gives also shows that at least some of them are not flat, like the spicules of *Veretillum*, but thick and warty all over.

These thick spicules with dentate or warty processes on the surfaces as well as on the edges are of such rare occurrence in Pennatulids and show such a close resemblance to a type of spicule that is commonly found in other groups of Alcyonaria that I think it may be used as the character that distinguishes the genus from the others.

The genus *Clavella* founded by GRAY in 1870 has according to the figure given by KÖLLIKER (Taf. XXI fig. 193) similar processes on the surface of the spicules. For this reason

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and for others put forward by BALSS (1910 p. 81) and by KÜKENTHAL and BROCH (1911 p. 170) I agree that *Clavella* can be merged into *Lituaria*.

KÖLLIKER distinguished *Clavella* from *Lituaria* by the presence of spicules in the body wall and tentacles of the anthocodiae but in his account of a specimen he named "*Lituaria phalloides?*" in the Challenger collection he states that there are spicules in the body walls and tentacles of the autozooids. It is quite clear, as BALSS points out, that the presence or absence of spicules in the anthocodiae cannot be relied upon as the sole character of generic importance but I am inclined to think it may be of some use in making specific distinctions.

In 1887 MARSHALL and FOWLER ((2) p. 282) described some specimens from the Mergui archipelago and Andaman Islands under the name *Lituaria phalloides*. They are long cylindrical forms and correspond in many respects with the description of the species by KÖLLIKER but as these authors made no mention of the spicules it must be a matter of some doubt whether their identification of the genus or species is correct. A specimen in the Manchester Museum labelled "*L. phalloides* Malay Seas" has the same shape and appearance as the one figured by MARSHALL & FOWLER and bears the typical thick, dentate spicules.

In 1909 THOMSON and SIMPSON described a new species on the investigation of several specimens from different localities in the Indian Ocean and gave it the name *L. Hicksoni*.

This species differs from *L. phalloides* in having a decidedly more pronounced club shape, (i. e. it is less elongated and cylindrical in form) and in having an armature of spicules in the body wall of the autozooids.

In 1910 BALSS described a new species *Lituaria Harbereri* based on the examination of a single specimen from Japan.

BALSS seems to have been unacquainted with the work of THOMSON and SIMPSON and no reference is made to it. It seems to me that these two species are identical and the name given by the scotch observers has precedence.

There remain then three species which may be arranged as follows: —

A. With a short axis . . . . . *L. australasiae* = *Clavella australasiae* Gray.
B. With a long axis
  a. Without spicules in the anthocodiae . *L. phalloides* Pall.
  b. With spicules in the anthocodiae . . *L. Hicksonii* Thomson & Simpson.

The genus cannot be very definitely separated from the other genera of Veretillidae except by the character of the thick double club or capstan shaped spicules in the rachis.

An axis is present in all species but does not extend the whole length of the colony in *L. australasiae*. An incipient radial symmetry is shown in some specimens of *L. phalloides* (see p. 39 footnote).

1. *Lituaria Hicksonii* Thomson and Simpson (Textfigs 4 & 5).

Lituaria Hicksoni Thomson and Simpson. Indian Alcyonaria 1909, p. 310, Pl. VI.
Lituaria Habereri Balss. Japanische Pennatuliden 1910, p. 81, Pl. .
Veretillum phalloides? Dana. Zoophytes 1848 p. 590.
Lituaria phalloides? Kölliker. Challenger Pennatulida, 1880. p. 32.

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Stat. 51. Molo Strait 69—91 metres. 1 Ex.
Stat. 240. Banda Reef. 9—36 metres. 1 Ex.

These two specimens are in size, colour and form unlike each other and yet they exhibit a remarkable similarity in their spicular armature and are alike in possessing an angular axis which extends the whole length of the colony. Both specimens are quite radially symmetrical. In external features, the larger specimen from the Molo Strait is like a specimen of *Veretillum cynomorium*, the smaller specimen is more like a *Cavernularia* but a detailed examination of the minute structure renders it very difficult to come to any other conclusion than that they belong to the same species.

The study of these two specimens adds to the difficulties of systematists by bridging the gap between *Lituaria* and *Veretillum* on the one hand and between *Lituaria* and *Cavernularia* on the other, and by emphasizing the conclusion that there are no differences of importance separating the so called genera of the Veretillidae.

The two specimens agree more closely with the description given of *Lituaria Hicksoni* by THOMSON and SIMPSON than with that of any other species and although I believe that this species must eventually be merged with *Veretillum* I propose to retain it provisionally in order to call special attention to the points of its structure.

The type specimens of the species came from a wide area in the Indian Ocean, the localities being: Persian gulf 128 metres, Indus delta 66 metres, and Orissa coast in the Bay of Bengal 56 metres. The species therefore does not appear to be simply a local variety.

It is very difficult to find any difference of importance between the description of *L. Hicksoni* and that of *L. Habereri* of BALSS and if, as seems probable, these two species are identical, its range extends to Japanese waters, 150 metres.

BALSS considers that the specimen described as *L. phalloides* by KÖLLIKER (1880) from Kobi, Japan is probably the same as his species *L. Habereri*. With that I am in agreement.

The measurements of the two specimens are as follows: —

	Station 51.	Station 240.
Total length	162 mm.	48 mm.
Length of rachis	102 „	29 „
Length of stalk	60 „	19 „
Diameter of rachis . . .	12 „	5·5 „
Diameter of stalk. . . .	7 „	3 „

Specimen from Station 51.

The colony is club shaped. At the distal end of the rachis the autozooids are crowded together but irregularly distributed without any arrangement in longitudinal or transverse rows. At the proximal end they are smaller and much more widely separated but still without any orderly arrangement. The siphonozooids are very numerous and irregularly distributed between the autozooids.

Nearly all the autozooids are fully expanded. The anthocodiae at the distal end of the rachis are about 10 mm. in body length by 2 mm. in diameter and the tentacles in some specimens 10 mm. in length. The specimen described by BALSS had "polyps" 5 mm. in length

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and 2—3 mm. in diameter with tentacles 2 mm. in length. Unfortunately BALSS gave no measurements of his specimen nor statement in the description of the Plates as to the magnification of the figures. It is impossible therefore to compare these measurements.

Fig. 7. *Lituaria Hicksonii.* Banda specimen. Spicules of the rachis. × 128 diam.

The spicules of the rachis are not densely crowded together. They are of various shapes (Fig. 4 p. 19 and fig. 7) but the double clubs or "capstans" predominate and all the larger spicules have thorny extremities. The important point about these spicules is that they are not flat. In optical section they are seen to be oval or round like the double club spicules of many of the Alcyonacea and I judge from the description and figures given by THOMSON and SIMPSON and by BALSS that this is the case also with the spicules of the rachis in the specimens they have described (*L. Hicksoni* and *L. Habereri*).

Many of the spicules have a form which THOMSON and SIMPSON describe as "like irregular cervical vertebrae" but I have found very few crosses whereas in the type "crosses are abundant".

The size of these spicules is very variable but the figures 0.1 × .075 mm. represent the size of an average "capstan". In the body wall of the anthocodiae there is a thin layer of spicules having the form of rods, dumbell-shaped twins, quadruplets etc. all with jagged edges but these spicules are all quite thin plates. There are very few spicules in the tentacles and in most of them I could find none at all.

There are numerous spicules in the cortex of the stalk. These are oval and quite smooth in outline or smooth rods. They are of a more uniform size than the spicules of the rachis and are about .08 mm. in length. They are not flat but oval in optical section.

The axis extends the whole length of the colony. I have not exposed it for its whole length but in the middle of the rachis where it is broken and exposed it is almost oval in section with a deep groove on one side. The colour of this specimen is uniformly pale yellow.

The specimen from Station 240 is also club shaped. The autozooids are more regularly arranged but are rather more widely separated than in the other specimen. The autozooids are partly contracted and many of them show shallow verrucae. The siphonozooids are irregularly scattered between the autozooids. The rachis passes gradually into the stalk without constriction. The endoderm of the tentacles, body wall of the autozooids and canal system of the rachis is charged with numerous brown granules.

The autozooids are not fully expanded, the anthocodiae are not more than 2 mm. in length and one millimetre in diameter. The tentacles are about 2 mm. in length.

The spicules have approximately the same shape size and distribution as in the specimen from Station 51 but the spicules in the cortex of the rachis are much more densely crowded.

The flattened spicules of the body wall of the anthocodiae can be seen to be arranged in eight intermesenteric longitudinal bands. There are no spicules in the tentacles.

The axis was not full exposed but it certainly extends nearly the whole length of the colony. A considerable part of the axis protrudes from the basal end of the stalk and is bent round as a hook. This part of the axis is cylindrical but a piece of the axis that has been exposed by dissection is quadrangular and 0.5 mm. across each surface.

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The colour of the rachis is bluish-grey, of the stalk pale yellow. As mentioned above however cleared preparations of the autozooids and thin slices of the rachis show a brownish colour due to pigment granules in the endoderm. The bluish grey colour must be, I imagine, a reflexion colour from the surface of the spicules.

Genus **Veretillum** Cuvier.

Veretillum Cuvier. Tableau elementaire. 1798, p. 675.
Veretillum Herklots. Polypiers nageurs. 1858, p. 26.
Veretillum + *Policella* Gray. Catalogue of Sea pens. 1870, p. 33.
Veretillum + *Policella*. Kölliker. Die Pennatuliden. 1872, pp. 324 & 316.
Policella Marshall and Fowler. Pennatulida of Mergui. 1887, p. 284.
Veretillum Kükenthal und Broch. Valdivia Pennatulacea. 1911, p. 175.

Veretillum is the name given by Cuvier to the *Pennatula cynomorion* of Pallas from the Mediterranean sea, and in this case there can be no doubt that the type of Cuvier's genus is the same thing as the *Veretillum* of Kölliker and subsequent authors.

We are fortunate in possessing a considerable knowledge of the anatomy of this genus owing to the researches of Kölliker (1872), Kükenthal and Broch (1911) and Niedermeyer (1914).

The genus *Policella* was established by Gray in 1870 for a specimen from Australia which he named *P. australis*. In the elaborate description of this genus given by Kölliker (1872) based on the investigation of specimens from the Philippine islands (*P. manillensis*), he lays stress on the absence of spicules in the rachis "Kalkkörper im Kolben ganz fehlend (p. 316)". But when he examined the type specimen of *P. australis* in the British Museum he found that spicules do occur in the rachis of this species. "Die Haut des Kolbens von *Policella australis* enthält zwischen den und nach aussen von den Längsmuskeln eine bedeutende Zahl grosser sonderbar geformter Kalkkörper (p. 322)". These spicules are flat biscuit-shaped bodies with strongly dentate edges, and not unlike, therefore, the spicules in the rachis of *Veretillum*. With the failure of this character the most important distinction between *Policella* and *Veretillum* breaks down and with the knowledge gained by the study of the two species represented in the Siboga Collection I have no hesitation in acting upon the suggestion made by Kükenthal and Broch (p. 176) to amalgamate the two genera.

If the two genera are amalgamated then the one distinguishing feature of the genus will be that the spicules are absent from the cortex of the rachis or, if present, in the form of flat plates.

The four species of the genus may be arranged as follows: —

A. With spicules in the anthocodiae . . . . . *V. cynomorium* (Pall.)

B. With no spicules in the anthocodiae

  a. With large (0.15 mm.) plate like spicules in the cortex of the rachis.

    1. With large autozooids . . . . . *V. malayense* new sp.
    2. With small autozooids . . . . . *V. australe* (Gray)

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b. Without spicules in the cortex of the rachis or with very minute otolith like bodies in this position

1. With large autozooids . . . . . *V. manillense* (Kölliker)
2. With small autozooids . . . . . *V. tenue* (Marshall and Fowler).

The difference between large autozooids and small autozooids is difficult to express in figures as the length of the anthocodiae in preserved specimens varies so much according to the care taken in preservation.

The following figures give some indication of what is meant.

	Large autozooids.	Small autozooids.
Length of expanded anthocodiae	12—14 mm. (Köll.)	6 mm. Köll.
	8—10 „ (M. & F.)	12—14 mm. (M. & F.).
	18 mm. Hickson.	
Diam. of expanded anthocodiae	1.1—1.4 mm. (M. & F.)	0.8 mm. (M. & F.).
	2 mm. (Hickson)	1 mm. Hickson.

1. *Veretillum tenue* Marshall and Fowler.

Policella tenuis A. M. Marshall and G. H. Fowler. Mergui Pennatulida. 1887, p. 285, Pl. XXII.

Stat. 213. Saleyer reef. —36 metres. 1 Ex.

This specimen agrees most closely with the description given by Marshall and Fowler of a specimen from the Mergui Archipelago. In the matter of measurements of the whole colony, they are remarkably alike as the following figures show; but there are one or two points of difference in detail which will be referred to in the text.

	Saleyer spec.	Mergui spec.
Total length	255 mm.	252 mm.
Length of rachis	192 „	184 „
Length of stalk	63 „	68 „
Diam. of rachis	12 „	13 „

The colony is cylindrical in form and comes to a blunt point at the distal end. The rachis passes directly into the stalk without constriction and the diameter of the upper part of the stalk is only 2 mm. less than that of the widest part of the rachis; but at the base there is a well marked thin-walled bulbous swelling 50 mm. in length and 18 mm. in greatest diameter. In the presence of this bulb the specimen apparently differs from the type.

The autozooids are nearly all completely retracted but those that remain partially expanded prove that the autozooids are small and slender. Marshall and Fowler give the figure 0.8 mm. as the diameter of the autozooids of this species and lay some stress on the slenderness of the autozooids as a character of the species. It is difficult to determine with accuracy the length and diameter of the autozooids of the Saleyer specimen but judging from those that are partially expanded the diameter cannot be more than 1 mm.

The siphonozooids occur on all sides of the rachis and in many places are arranged in

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irregular longitudinal lines. The dorso-ventral diameter of the stomodaeum of the siphonozooids is about 0.1 mm. and is therefore smaller than in the specimens of *V. malayense.*

No spicules were found in any part of the rachis but without entirely destroying the specimen it would be impossible to assert that spicules do not occur at all. Several thin slices of the cortex, fragments of the subjacent tissues and two partly expanded autozooids were cleared in oil and examined, a thick piece cut out of the rachis was boiled in potash for many hours and the precipitate examined but no spicules were found. If spicules do occur at all they must be very scarce and scattered.

In the superficial layers of the stalk no spicules were found but in the muscular layer, small oval or round, rather thick calcareous corpuscles occur in groups and irregular rows. The largest of these spicules are .03 mm. in length but the greater number are from .01—.003 mm. in length or in diameter.

The axis appears to be well developed extending from the distal end of the rachis to tho basal bulb of the stalk. It was not laid bare for its whole length but, in the thickest part of the rachis where it was exposed, it is quadrangular in section with deep grooves on the surfaces, very rounded angles and about 2 mm. in thickness.

The specimen was a female, the eggs being 0.3 mm. in diameter. The colour is uniformly white.

In the description of the type specimen MARSHALL and FOWLER say that there are a few small calcareous bodies in the rachis and give figures of an oval and rod-shaped spicule 0.6 mm. in length. In this respect, then, the Saleyer specimen differs from the type. The axis is almost certainly longer than that of the type but not so thick. It has the same shape; quadrangular with rounded angles and deeply grooved sides.

2. *Veretillum malayense* n. sp. (Pl. I, fig. 1 and textfig. 8).

Stat. 47. Bay of Bima. 55 metres. 2 Ex.

The larger of the two specimens has an appearance very similar to that of *Policella manillensis* as drawn by KÖLLIKER in his Pl. XXII, fig. 189 (1872) but at a distance of 25 mm. from the distal end of the rachis there is a dome shaped projection 15 mm. in height and 10 mm. in diameter bearing a normal number of autozooids and siphonozooids. This process may be regarded as a deformity which ought not to be taken into consideration in the definition of the species. A similar deformity has been described by MARSHALL and FOWLER (1887 p. 281) in a variety of *Cavernularia obesa*. The suggestion they make that this deformity is associated with the absence of a calcareous axis, however is not supported as in this case there is a well developed axis.

As regards the general form and size of the autozooids the specimens show close affinities with KÖLLIKER's *Veretillum manillense (Policella manillensis).* It differs from this species however in the presence of large flat plate like spicules in the rachis. In this respect it resembles *V. australe (P. australis)* of GRAY but differs from it by its large autozooids. There is really so little difference of importance between these species that it is probable that all

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the species of the genus will be merged into one, but provisionally it seems advisable to keep the Siboga specimens apart from the others as a new species *V. malayense.*

The principal measurements of the two specimens are as follows: —

	Spec. 1.	Spec. 2.
Total length	140 mm.	68 mm.
Length of rachis . . .	102 „	37 „
Length of stalk . . .	38 „	31 „
Diameter of rachis . .	16 „	7 „
Diameter of stalk. . .	8 „	2 „

The rachis is club shaped ending above in a broad domeshaped extremity. It passes gradually into the stalk. There is no apparent basal bulb in either specimen. The autozooids are nearly all fully expanded and between the autozooids there are ridges on the rachis forming a pattern similar to that shown in KÖLLIKER's figure of the type of *Policella manillensis.*

The expanded part of the autozooids vary in size but (in Spec. 1) have an average body length of 18 mm. and diameter 2 mm. The tentacles are about 4 mm. in length. The stomodaeum is very long extending nearly the whole length of the anthocodia. The autozooids are therefore much larger than those of *V. tenue* described above (p. 47).

The siphonozooids are widely scattered over the rachis and do not appear to be arranged in rows. They are a little larger than in *V. tenue* the stomodaea having a dorso-ventral diameter of 0.125 mm.

The spicules of the rachis are very thin plates, many of them so thin and transparent that they may be easily overlooked in a strong light. In both specimens they are few in numbers and in some parts of the rachis widely separated.

The predominant form of spicule is a thin dumb-bell shaped plate sometimes divided in the middle by a faint line. The larger of these plates are about 0.15 mm. in length and show dentate edges. The smaller ones have smooth edges. In addition to these there are particularly in the larger specimen, a number of flat rods and spindles which also in some cases show dentate extremities. The length of these rods varies considerably, the largest I have measured are 0.225 mm. in length. They are also sometimes divided by a median line.

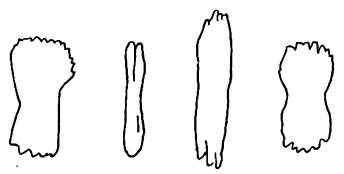

Fig. 8.
Veretillum malayense. Station 47.
Spicules of the rachis. × 110 diam.

These spicules differ therefore very markedly from the small otolith-like bodies (.008 × .004 mm.) described by MARSHALL and FOWLER (1887 (2) p. 284) in a specimen of *Veretillum (Policella) manillensis.*

There are no spicules in the body wall or tentacles of the autozooids. In the cortex of the stalk there are a few rod shaped spicules.

The axis extends to the proximal end of the stalk from which it protrudes as a hook in the larger specimen. In the middle of the rachis it can be seen as a thick quadrangular rod 1 mm. in diam. and it can be felt with a probe a few millimetres from the end.

The colour of both specimens is uniformly pale yellow.

The new species may be briefly described as follows: —

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Colony club shaped with large autozooids. Large flat plate like spicules in the cortex of the stalk. Axis quadrangular in section. Bay of Bima 55 metres.

Genus **Cavernularia** Valenciennes.

Cavernularia Milne-Edwards Haime. Hist. nat. Coralliaires. 1857, Vol. I, p. 219.
Cavernularia + *Sarcobelemnon* Herklots. Polypiers nageurs. 1858, p. 25.
Cavernularia + *Stylobelemnon* Kölliker. Die Pennatuliden. 1872, pp. 336 and 348.
Fusticularia Simpson. Ann. N. H. 1905, p. 561, Pl. XVII.
Cavernularia + *Cavernulina* Kükenthal und Broch. Valdivia Pennatulacea. 1911, pp. 172 and 180.

The name *Cavernularia* was given by Valenciennes to a specimen of the Veretillidae in the Paris Museum. The name and a very brief description was written on a label attached to the specimen and they appeared for the first time in a published form in the Histoire naturelle des Coralliaires by Milne-Edwards and Haime 1857.

Kölliker in 1872 merged the genus *Sarcobelemnon* founded by Herklots with *Cavernularia* but established a new genus *Stylobelemnon* for *Cavernularia pusilla* of Herklots on the ground that it possesses a well developed axis.

Finally in 1911 Kükenthal and Broch merged the genus *Stylobelemnon* with *Cavernularia* but founded a new genus *Cavernulina* for a specimen from Amboyna with branched spicules in the rachis.

The principal characters given by Kölliker to distinguish the genus are: —

Autozooids small, completely retractile, and without spicules. Axis short or absent. Spicules long and narrow without ridges (ohne Kanten).

In the description of the genus given by Kükenthal and Broch (p. 180) the spicules of the rachis are described as follows: — "Im Polyparium sind ovale bis stabförmige unverzweigte Spicula in Mengen vorhanden".

The definition of the genus as given by Kölliker is open to much criticism in the light of modern observations. Although it is true that the autozooids in most of the species are small as compared with those of *Veretillum* and usually completely retracted, they appear to be larger and less retractile than usual in the specimen described as *Cavernularia Chuni* by Kükenthal and Broch p. 190. Again the spicules are not usually found in the body wall of the anthocodiae but are undoubtedly present in this position in *Cavernularia pusilla* (Kölliker p. 348 and Kükenthal and Broch p. 192).

As Balss (1910 p. 83) has shown that, in *Cavernularia Habereri*, some specimens from the same locality are found without an axis and some with one, and as his view concerning the variability of the axis is confirmed by the researches of other observers, it is clear that the character of the axis cannot be relied upon for a generic distinction.

It seems, necessary therefore, to look to the spicules and particularly to the spicules of the rachis for the principal distinguishing character of the genus.

There can be no doubt that in the majority of specimens attributed to the genus the spicules of the cortex of the rachis are long, narrow, smooth rods or spindles and that they form a good character for distinguishing a specimen from a *Veretillum* or a *Lituaria* but there are

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some species which must be retained within the genus in which varieties of this form of spicule occur. Thus in the description of *Cavernularia obesa*, KÖLLIKER refers to the occurrence in the rachis of spicules of the form of "gestreckten Keulen, gestreckten Doppelkegeln mit zugespitzten, abgerundeten, quer abgeschnittenen oder kurz zackigen Enden" and KÜKENTHAL and BROCH (1872 p. 189) in their reference to *Cavernularia glans* write "Die langen sehr unregelmässig stabförmigen Spicula des Stielinnern sind schlank und haben breit abgerundete bis fast quer abgeschnittene Enden, die nicht selten geteilt sind, und ab und zu finden wir auch Spicula die an einem Ende spitz auslaufen". In *C. malabarica* (Fowler) a few spicules of the rachis are bifurcated and some carry a prominence.

There can be no doubt that in the species that are well established as species of *Cavernularia*, spicules with branched extremities do occur and that to separate *Cavernularia orientalis* (Th. and S.) from the genus on account of the branched spicules of the rachis is not sound policy. (For further discussion of this point see p. 54).

There is a better distinction between the branched or unbranched spicules of *Cavernularia* and the flat plate-like or "biskuitförmige" spicules of the genus *Veretillum* but, no doubt, cases will be found of colonies bearing spicules of an intermediate kind and the only real distinction between the two genera will break down.

The following general statement may serve for the time being as a definition of the characters of the genus; —

Colonies usually club shaped with small and usually completely retractile autozooids. Spicules of rachis rod-shaped and occasionally branched at their extremities. No spicules in the tentacles of the autozooids and rarely (*C. pusilla*) in the body walls of the anthocodiae. Axis frequently absent, sometimes abbreviated, rarely complete. —

It is extremely difficult to formulate a key for the species of *Cavernularia* that are recognised by modern authorities. Bearing in mind the extraordinary variability that some of the so-called species are known to exhibit as regards the axis, the spicular armature and other details of structure and further that some of the well-known forms (e. g. *C. obesa*) have a very wide geographical distribution in shallow water, there can be little doubt that it would be the best plan to recognise them all as varietiès of one species *Cavernularia obesa*.

As such a plan may not be regarded at present as ripe for acceptance I submit a scheme which may be useful but is in my opinion quite artificial.

A. Without an axis

C. obesa M. E. & H. 1857.
C. elegans Herklots 1858.
C. Chuni Kükenthal and Broch 1911.
C. Herdmani Simpson 1905.
C. madeirensis Studer 1878.

B. With an imperfect or variable axis

C. Harbereri Moroff 1902.
C. marquesarum Balss 1910.
C. glans Köll. 1872.

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C. malabarica Fowler 1894.
C. orientalis Th. and S. 1909.
C. andamanensis Th. and S. 1909.

C. With a complete axis

C. Lütkeni Köll. 1872.
C. pusilla Herklots 1858.
C. clavata K. & B. 1911.

Cavernularia elegans apparently differs from the type *C. obesa* in having no spicules in the inner parts of the stalk.

Cavernularia Chuni was founded on a single specimen from Coamong (?) and differs from *C. obesa* with which it has affinities in the great number and variability of the spicules in the inner parts of the stalk.

C. Herdmani also founded on a single specimen from Cingalese waters is probably a young form of *C. obesa*. It differs from the type in the great variability of the spicules and the remarkable palmate forms they include. It was described under the new generic name *Fusticularia*. *C. madeirensis* (Studer 1878, p. 674) differs from *C. obesa* in the great size and small number of the autozooids.

C. Harbereri differs from *C. obesa* in the presence of an axis in some specimens and according to KÜKENTHAL and BROCH (p. 184) in the entire absence of spicules in the cortex of the middle region of the rachis. *C. marquesarum* is probably a variety of *C. Harbereri* but has larger spicules in the rachis. In *C. glans* an axis may or may not be present. The spicules of the stalk differ from those of *C. obesa* in being always much longer and narrower and some of them are split at the extremities. *C. orientalis* and *C. andamanensis* exhibit many spicules that are branched at the extremities. They appear to me very closely related, but *C. orientalis* has a cylindrical axis and *C. andamanensis* a square axis.

C. malabarica (Fowler 1894) founded on the study of six specimens has only a few spicules with bifurcated extremities in the rachis but it also shows some "Vierlinge".

C. Lütkeni is evidently closely related to *C. obesa* but apart from the presence of an axis it differs from the genu-type in having few spicules in the inner parts of the stalk. *C. pusilla* is distinguished from all the other species by having a dense cluster of spicules round the base of the anthocodiae and spicules in their body walls.

C. clavata was founded on a single specimen from Formosa. It is apparently related to *C. pusilla* but differs from it in the absence of spicules in the body wall of the anthocodiae and by the thicker and stronger spicules of the cortex of the rachis.

1. *Cavernularia orientalis* Thomson & Simpson. (Textfig. 9).

Cavernularia orientalis Thomson & Simpson 1909. Indian Alcyonaria. p. 305.
Cavernulina cylindrica Kükenthal & Broch 1911. Valdivia Pennatulacea. p. 172, Pl. XVIII.

Stat. 181. Amboyna anchorage. 4 Ex.

There are four specimens from this locality which have given me some trouble in iden-

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tification as they exhibit so much variation in their armature of spicules. They have the following measurements: —

	1.	2.	3.	4.
Total length . . .	113 mm.	90 mm.	48 mm.	40 mm.
Length of rachis . .	99 „	55 „	28 „	24 „
Length of stalk . .	14 „	35 „	20 „	16 „
Diameter of rachis .	13 „	10 „	10 „	9 „
Diameter of stalk. .	7 „	6 „	6 „	8 „

The club shaped colonies have the appearance of a typical *Cavernularia*. The autozooids and siphonozooids are scattered quite irregularly on all sides of the rachis, there is no evidence of an arrangement of the zooids either in longitudinal or transverse lines and there is no trace of a dorsal or ventral track.

They appear to be absolutely radially symmetrical.

The rachis passes gradually into the stalk without any constriction in all the specimens except the largest in which, owing probably to post mortem contraction, there is a slight constriction and the upper part of the stalk is corrugated. The distal end of the rachis is rounded or dome-shaped and the proximal end of the stalk is conical in all the specimens except the smallest in which it is swollen to form an end bulb.

In the larger specimens a number of the autozooids show a semicircular or circular, collar or lip-like verruca supported by spicules but it is certain that this verruca can be completely withdrawn. Only a few autozooids are expanded. The diameter of these autozooids is about 1 mm., and the length of the anthocodia as preserved is 1 mm. The autozooids of this species therefore are small.

The siphonozooids are of medium size the dorso-ventral diameter of the stomodaeum being about 8.13 mm.

The spicules of these specimens exhibit very great variety but there is a marked difference between the spicular armature of specimen 3 and that of specimen 1 and 2.

A preparation of the cortex of the rachis of specimen 1 or 2 shows a dense network of spicules lying parallel with the surface the meshes of which afford openings for the autozooids and siphonozooids. The impression one gains by the examination of such a preparation is that nearly all the spicules are bone-shaped, that is to say rod-shaped spicules with bifurcated extremities. A macerated specimen of the same region however shows that in addition to these bone-shaped

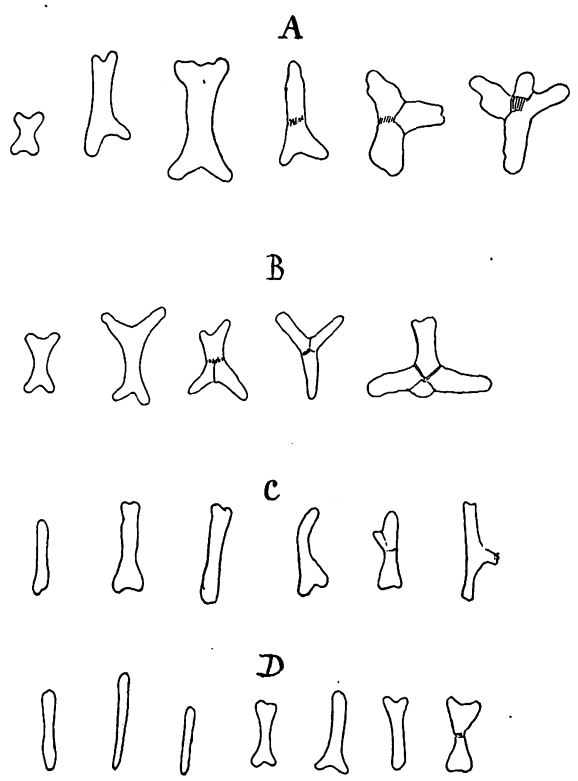

Fig. 9. *Cavernularia orientalis.*
Spicules of the rachis of (A) specimen 1, of (B) specimen 2 and of (C & D) specimen 3. All × 70 diam.

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spicules there are a great many others of various excentric shapes, some triplets some quadruplets etc. They are all quite flat and show no superficial ridges.

They are so variable in size that it is difficult to give measurements. The largest may be 0.3 mm. or more in length.

When a preparation of a piece of the cortex of the rachis of specimen 3 is examined, however, the network of spicules is found to be much less dense and the predominating type is a simple rod with rounded undivided extremities. The macerated preparations of the same specimen however show a few spicules with one or both extremities divided.

In the cortex of the stalk of specimens 1 and 2 we find a dense crowd of round, oval and a few rod-shaped spicules of a fairly uniform length of 0.08 mm. These spicules are not thin flat plates like the spicules of the rachis but of considerable thickness. As this is a point of some importance I have confirmed the impression gained by focussing on to the preparation of a horizontal section by the study of vertical sections in which the spicules can be seen edgeways. It is very difficult to determine accurately the thickness of these spicules but after prolonged study I can say that the spicules with a circular outline are almost spherical in shape, that the oval spicules with a length of .08 mm. have a thickness of .05 mm. and that the few rod-shaped spicules are almost flat.

In the cortex of the stalk of specimen 3 the spicules are nearly all flat rods 0.8 mm. in length by about 0.3 mm. in breadth. Among the rods however a few round and oval spicules may be seen. These spicules are very much less numerous than the spicules in a corresponding position in the specimens 1 and 2, and appear to be all quite flat.

A few spicules of many shapes and sizes occur at the base of the anthocodiae and round the mouths of the siphonozooids. These spicules do not exhibit any special orderly arrangement to support true calices but they interfere to some extent with the final effort of retraction of the autozooids and therefore frequently give rise to pseudocalices or verrucae. There are no spicules in the upper parts of the anthocodiae nor in the tentacles.

In the deeper layers of the rachis of specimen 2, a large number of spicules were found. They do not differ from the spicules of the cortex of the rachis.

The axis is quadrilateral with a deep groove on each of the four surfaces. I have not determined its full extent but it certainly extends almost to the distal end of the rachis and more than half way down the stalk.

All the specimens are white.

There seems to be no reason to separate these specimens from the *Cavernularia orientalis* of THOMSON and SIMPSON (1909 p. 305), but according to KÜKENTHAL and BROCH (1911 p. 172) this species and the *Cavernularia andamanensis* of the same authors probably belong to the genus *Cavernulina* K. & B.

This new genus was founded in 1913 for a single specimen from Amboyna and there can be little doubt that the Siboga specimens from the same locality are identical with the *Cavernulina cylindrica* of KÜKENTHAL and BROCH.

The characters that are supposed to distinguish *Cavernulina* from *Cavernularia* have

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reference almost entirely to the spicules. In the former the spicules of the rachis are said to be branched at the extremities, in the latter unbranched. These spicules are variable in *Cavernulina* but do not show the same variability in *Cavernularia*.

According to these authors there is a further difference between the two genera in that in *Cavernulina* there is an outer coat in the cortex of the stalk which is free from spicules whereas in *Cavernularia* the spicules are at the surface.

The character that the spicules are or are not branched at the extremities does not appear to me sufficiently important to justify a generic or even a specific distinction. We have in this collection one specimen with spicules that are only exceptionally bifurcated at the extremity and two in which nearly all the spicules of the rachis show this peculiarity. It is quite incredible that specimen 3 from the same dredging as specimens 1 and 2 is a representative of a different genus. If we were to rely upon this character alone there can be no doubt that specimen 3 would be placed in the genus *Cavernularia* and 1 and 2 in the new genus *Cavernulina*.

After reference to the great variability of the spicules of *Cavernularia orientalis* as described by THOMSON and SIMPSON, KÜKENTHAL and BROCH (1911 p. 173) say "Von uns angestellte Untersuchungen ergaben aber mit voller Sicherheit, dass eine derartige Spiculavariation bei *Cavernularia* nicht existirt".

With this statement may be compared that of KÖLLIKER (1872 p. 339) in describing the spicules of *Cavernularia obesa* "Kalkkörper des Kolbens von der Form von Walzen, Spindeln, Griffeln, gestreckten Keulen, gestreckten Doppelkegeln mit zugespitzten, abgerundeten, quer abgeschnittenen oder kurz zackigen Enden" and the figures on his Plate XXIII 205. Or it may be compared with the more general statement of BALSS (1910 p. 86) that the extraordinary variability of the spicules gives the diagnosis of species but little value.

It is very probable that the spicules of some species or of some specimens of *Cavernularia* show a greater variability than others, but this degree of spicule variability is surely not a matter on which a generic distinction can be made.

As regards the outer coat of the stalk that is free from spicules in *Cavernulina* and said to be absent in *Cavernularia*; KÜKENTHAL and BROCH give no figure or description of the histological structure to show of what it consists.

In sections through the cortex of the stalk of the Amboyna specimens I have found that in some places there is a thick epithelium quite free from spicules covering the densely crowded layer of spicules in other places this epithelium has been worn away and the spicules are exposed to the surface. The superficial epithelium of the stalk in this as in other Pennatulacea is probably very soft and readily detached when preserved in spirit, but there is little reason to suppose that a structure of such great morphological importance should be present in one genus of a family and absent in another.

The spicules of the cortical layer of the stalk show some variation in thickness, those of specimens 1 and 2 being much thicker than those of specimen 3. In outline they resemble more closely the oval to rod-shaped spicules of the stalk of species of *Cavernularia* than the "knochen- bis stabförmig" spicules of *Cavernulina*.

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Family ECHINOPTILIDAE.

Echinoptilidâe Hubrecht. 1885. Proc. Zool. Soc. p. 517.
Echinoptilidae ex parte. Kükenthal & Broch. 1911. "Valdivia" Pennatulacea. p. 201.

The family Echinoptilidae was founded by HUBRECHT (1885 p. 517) for the two specimens of *Echinoptilum M'Intoshii* that he described.

In 1911 KÜKENTHAL and BROCH (p. 201) added the genus *Actinoptilum* and included the family in their Section, — the *Pennatulacea radiata*. This arrangement appears to me to be open to many objections. *Actinoptilum* is supposed to resemble *Echinoptilum* in having calices for the autozooids and in the absence of an axis. The first of these characters is not of much importance. In *Actinoptilum* the so-called "calices" are very short, supported by a fan-shaped arrangement of rachis spicules, and have a lip of shelf-like form (see also p. 41). They are really not calices but verrucae. In *Echinoptilum* the calices are of considerable length, they embrace the base of the anthostele and are provided with two prominent teeth. The second character — the absence of an axis — *Actinoptilum* shares with many of the species of *Cavernularia* as well as with *Echinoptilum*. It is quite true as KÜKENTHAL and BROCH remark (p. 196) that the absence of an axis is no argument against the establishment of the family, but on the other hand it affords no strong reason in favour of the view that *Actinoptilum* should be included in the family Echinoptilidae.

The principal reason for keeping *Echinoptilum* alone in the family is that it is the only genus in which we find a definite bilaterality combined with the absence of an axis. The rachis is not radially symmetrical as it is in all the Veretillidae including *Actinoptilum* but is bilaterally symmetrical. This bilateral symmetry is shown in two ways. On the ventral [1]) side of the rachis there is a track of variable length that is free from zooids, and in the transverse rows of autozooids those (i. e. the autozooids) on the dorsal side of the rachis are the oldest and largest and those on the ventral or ventro-lateral sides are the youngest and smallest (Plate V, fig. 29). In other words, apart from the presence of a ventral track, there is never any difficulty in distinguishing the dorsal, the lateral and the ventral sides of the rachis. This cannot be done in *Actinoptilum* nor in any of the Veretillidae.

As regards the ventral track, KÜKENTHAL and BROCH examined 48 specimens of *Echinoptilum* and found a ventral track varying in length from 5—28 mm. in all specimens except two By a curious coincidence I have also examined 48 specimens of the genus and have found the ventral track well marked in all of them.

This track occurs therefore in about 98% of the specimens examined and indicates a bilateral symmetry quite as definitely as in such a species as *Sclerobelemnon Burgeri* which belongs to the bilateral family Kophobelemnonidae.

Moreover in the two specimens mentioned by KÜKENTHAL and BROCH which show no ventral track there is no evidence that the difference in size between the dorsal and ventral autozooids does not occur as in the other forms.

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1) It may be regarded as an assumption based only on comparative anatomy that this is the ventral side. It has not been proved by embryology. But if it is proved to be dorsal the argument still holds good.

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It is inconceivable to me how a scientific description of the genus can begin with the words: "Radiär gebaute Seefedern, die durch das Vorkommen eines grösseren oder kleineren ventralen Kielfeldes zur äusserlichen Bilateralität neigen" (KÜKENTHAL and BROCH 1911 p. 197). The facts of the case are that *Echinoptilum* is a bilaterally symmetrical sea-pen as shown externally by the presence of a ventral track free from autozooids and by transverse series of autozooids of successive ages from the dorsal to the ventral sides, and internally by the arrangement of the great longitudinal canals (Pl. V, figs 31 & 32). Only in rare cases is the ventral track absent or obscure.

As there is only one genus, the characters that distinguish the family Echinoptilidae are the characters of the genus.

Genus **Echinoptilum** Hubrecht.

Echinoptilum Hubrecht. Proc. Zool. Soc. 1885 p. 512, Pl. XXI and XXII.
Actinoptilon (ex parte) Kükenthal. Zool. Anz. XXXVI, 1910, p. 57.
Echinoptilum Balss. Jap. Pennatuliden 1910, p. 37, Pl. II.
Echinoptilum Kükenthal and Broch. "Valdivia" Pennatulacea 1911, p. 196, Pl. XVIII and XIX.
Echinoptilum Nutting. Proc. Nat. Mus. XLIII, 1912, p. 48.

The genus *Echinoptilum* was first described by HUBRECHT in 1885. Our knowledge of it has since been extended by the researches of BALSS and of KÜKENTHAL and BROCH.

The characteristics of the genus are: —

Club-shaped Pennatulacea with bilateral symmetry indicated by the presence of a ventral track on the rachis. Autozooids arranged in transverse or oblique rows or more unevenly scattered on the rachis. The largest autozooids on the dorsal side. Each autozooids supported by a well defined calyx with two teeth. Siphonozooids scattered on the rachis and frequently provided with minute verrucae.

Spicules frequently red or orange in colour, 3-flanged needle or rod-shaped in the calices, rachis and stalk. Axis absent.

Only two species have hitherto been described *E. M'Intoshii* Hubrecht and *E. echinatum* Kükenthal. HUBRECHT's two specimens of *E. M'Intoshii* were obtained in 130 metres off the coast of Japan and the species was rediscovered by Doflein's expedition in 100 metres of water off the same coast and described by BALSS. NUTTING (1912) records the same species off Hawaii in 169 metres but as he gives no figures or description of his specimens it may be considered doubtful whether they are more closely related to the type specimens of this species or to the species that have subsequently been described.

KÜKENTHAL (1910 (2) p. 57) described a species under the name *Actinoptilon echinatum* obtained by the "Valdivia" expedition off the Somaliland coast in 628 metres. This species was renamed *Echinoptilum echinatum* by KÜKENTHAL and BROCH (1911 p. 196).

The "Siboga" expedition obtained specimens belonging to the genus from five stations in the Malay archipelago and these specimens can be arranged into four well-marked groups which exhibit characters intermediate between HUBRECHT's and KÜKENTHAL's species.

The problem presented to the systematist in this case is the choice between two courses.

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He may regard the different forms that occur as varieties of one widely distributed and variable species or he may regard the different groups as distinct species.

I have decided to adopt the latter course for several reasons. The four groups found within the area of the Malay archipelago differ from one another as much as they differ from the species of the Japanese waters and of the Somaliland coast. The differences between the forms cannot be correlated with differences of depth nor of habitat nor can they be satisfactorily explained as differences in age or growth of one species: Moreover, in the early days of the study of a genus a careful description of the characters that are supposed to separate new species attracts attention to details of structure and anatomy which may have importance in future investigations, a hasty process of lumping everything into one species tends to check detailed study of individual peculiarities.

Nevertheless I am quite prepared to believe when further study or this interesting genus has been made that there is only one variable species of the genus *Echinoptilum* and await with interest the discovery of specimens from intermediate districts such as the Philippine islands, the Andaman islands and the Southern parts of the Indian Ocean.

Comparison of the Species of *Echinoptilum*.

For purposes of comparison I have compiled the following table: —

SPECIES	Total length	Ratio of total length to length of stalk	Ratio of total length to diameter of rachis	Length of large spicules	Spicules of the stalk	Length of calyx teeth	Depth of habitat in metres
E. roseum	142	2.3	6.3	1 mm.	0.11 × .043 mm.	2 mm.	204
E. elongatum	60	2.3—3.3	17—22	0.7 mm.	0.55 × .043 mm.	1.3 mm.	88
E. asperum	48	2.4—3	3.3, 4.8	1.5 mm.	0.157 × .02 mm.	2 mm.	724, 835
E. minimum	34	2.4—3.4	8.5	1 mm.	0.343 × .04 mm.	0.3 mm.	73
E. M'Intoshii . . . (HUBRECHT's specimens)	34	3.6	4.3	?	? ?	?	130
E. M'Intoshii . . . (BALSS's specimens)	115	4.6—6.1	7—8	?	? ?	?	100
E. echinatum	130	2—3	5—9	1 mm.	0.06 mm. in length	2.5—5	628

In the first column is given the length in millemetres of the largest known specimen of the species. In the second column is given the ratio of the total length to the length of the stalk, a ratio upon which KÜKENTHAL and BROCH lay considerable stress in their statement of specific characters.

It will be noticed that although there is a considerable difference between KÜKENTHAL's species *E. echinatum* and the type species *E. M'Intoshii* in this feature there is a close agreement between all the Siboga specimens and *S. echinatum*. In other words, it seems to be a special character of *E. M'Intoshii* to have an exceptionally long rachis.

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In the third column is given the ratio of the length to the maximum diameter of the rachis, a ratio which gives in figures some indication of the degree of slenderness or stoutness of the colonies. I am inclined to believe that this ratio is of greater value than the ratio of total length to length of stalk in the consideration of the relations of the species.

We notice in the first place that *E. elongatum* is much more slender than any of the other species. *E. minimum* approaches *E. M'Intoshii* and *E. echinatum* in this respect but *E. asperum* and *E. roseum* are comparatively stout.

The measurements given in the text show that the shorter and presumably older specimens of *E. elongatum* are not so slender as the larger ones, and I have noticed the same thing in the measurements of *E. minimum*

It seems probable therefore that, as the longest specimen of *E. minimum* in the collection is a great deal shorter than the shortest specimen of *E. M'Intoshii* described by Balss and of *E. echinatum* described by Kükenthal and Broch the species is distinguished from them by being a good deal more slender than the figures actually show.

The figures given in the fourth column are not very trustworthy. An examination of three or four preparations of the spicules of any species does not exclude the possibility that exceptionally large spicules occurring in the colony have been missed and the attempt to give an average of a large number of spicules in the preparation fails to convey a correct impression of the characters of the spicules present.

The figures for which I am responsible in this column represent the average length of the large spicules in two or three preparations, and in reckoning this average I have excluded a few spicules that seemed to be exceptionally large and all the small and very small spicules.

They express then the impression which the preparations give that the long needle spicules of *Echinoptilum asperum* are longer than in all the other species, that in *E. minimum*, when the size of the colonies is taken into consideration, the spicules are also remarkably long, and that in *E. elongatum* we find, for its size, the shortest of these long spicules (Fig. 10).

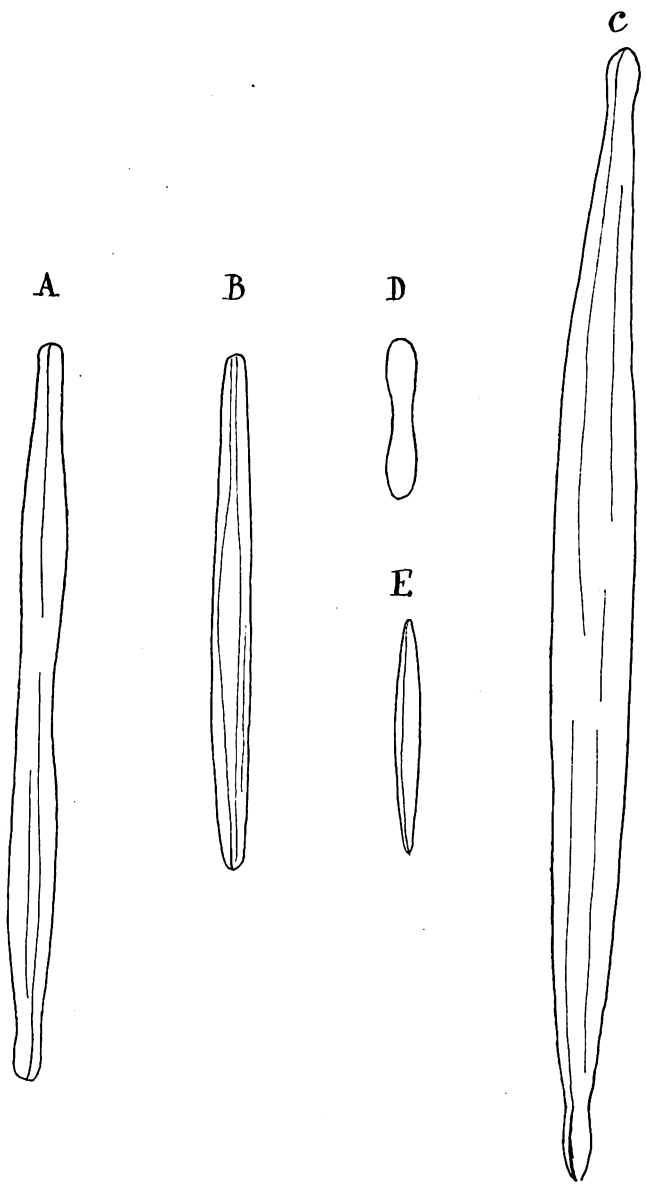

Fig. 10.
Spicules of the rachis of *Echinoptilum roseum* (A) of *E. elongatum* (B) of *E. asperum* (C).
Spicules of the tentacles of *E. roseum* (D) and of *E. asperum* (E).
All × 100 diam.

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In the fifth column are given the spicules of the superficial layers of the stalk.

In the sixth column there is expressed in figures, which may be regarded as more trustworthy, the impression that the specimens give that the calyx teeth of *E. echinatum* are exceptionally long, that they are also very long in comparison with the size of the colony in *E. asperum*, and that in *E. minimum* they are exceptionally short.

There are no measurements on record of the length of the calyx teeth of *E. M'Intoshii*, but judging from the figures given by BALSS, they appear to be short.

In the last column there is given the depths in metres from which the species were dredged in order to show that it is impossible to correlate any special characters exhibited with the depth at which they were found. It is true that the two echinate forms *E. echinatum* and *E. asperum* were found in depths of over 600 metres and that the species with exceptionally short calyx teeth were found in depths of less than 100 metres; but the evidence is by no means conclusive that these characters have been differentiated by bathymetric isolation.

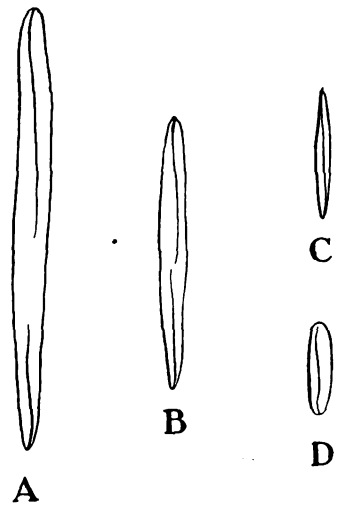

Fig. 11.
Spicules of the stalk of *Echinoptilum elongatum* (A), *E. minimum* (B), *E. asperum* (C), and *E. roseum* (D). All × 100 diam.

The spicules found in the superficial layers of the stalk exhibit some remarkable differences in the species examined (Fig. 11).

In *Echinoptilum roseum* these spicules are small and crowded, the predominant forms being 0.11 mm. in length by 0.035 mm. in breath. In *E. asperum* they are small, narrow coloured needles, and not so crowded as in *E. roseum*. The predominant forms are 0.157 mm. × 0.02 mm.

In *E. minimum* they are long and broad needles, crowded together, the predominant forms 0.34 mm. × 0.04 mm. In *E. elongatum* they are needles longer than in *E. minimum* and not so crowded together, the predominant forms being 0.43 mm. × 0.043 mm.

In *E. echinatum* according to KÜKENTHAL and BROCH the spicules of the "Stielrinde" are broad rod-shaped spicules. 0.06 mm. in length.

It seems therefore that in this character we find very remarkable confirmation of the view that the species are distinct. The largest forms *E. roseum* and *E. echinatum* have actually the smallest stalk spicules. *E. asperum* has very narrow stalk spicules, and *E. elongatum* the longest stalk spicules.

I have not examined very carefully the inner parts of the stalk for the small oval calcareous bodies found by KÜKENTHAL and BROCH in *E. echinatum* but I have not been able to find them in my preparations.

As regards the spicules of the anthocodiae. There are spicules in the axis of the tentacles in *E. roseum*, *E. asperum* (Fig. 10), *M'Intoshii* and *E. echinatum* but I have seen no spicules at all in the tentacles of *E. elongatum* and *E. minimum*. Spicules occur in the pinnules of the tentacles in *E. echinatum* (Kükenthal and Broch) but not in any of the "Siboga" species. I have seen a few small spicules in the body wall of *E. roseum* but not in the other species.

I am not inclined to lay much stress on the absence of the spicules from these parts as it is possible that in preservation or capture they may have been rubbed off such delicate

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tissues but the statements given are based on the examination of two or three preparations in each case.

The anatomy of *Echinoptilum M'Intoshii* has been studied by BALSS and of *Echinoptilum echinatum* by KÜKENTHAL and BROCH.

The four main longitudinal canals of the rachis in *E. elongatum* and in *E. minimum* have the same general arrangement as that described for *E. echinatum* by KÜKENTHAL and BROCH (1911 p. 5171, fig. 85) but the septa dividing them are proportionately thinner.

In *E. elongatum* the septa are thicker than they are in *E. minimum* (Pl. V, figs 31 & 32) and in the former a few endodermal canals can be seen in the dorso-lateral and ventro-lateral septa but none in the dorso-ventral septa (Pl. IV, fig. 28). In the latter no such canals can be seen in any of the septa.

E. elongatum also differs from *E. minimum* in having a much thicker cortical sarcosoma and a better developed muscular system. In both species the dorsal and ventral muscular bands are well developed (Pl. V, figs 31 & 32 *m. m.*) but in *E. minimum* the lateral muscles lying beneath the sarcosoma are thin and interrupted (*m'*).

BALSS (1910 p. 39) has described certain small canals surrounded by a circular ring of muscles in *E. M'Intoshii* which bring the cavities of the autozooids into communication with the lacunar system. KÜKENTHAL and BROCH describe similar canals in *E. echinatum* (p. 515) and in *Actinoptilum molle* (p. 519) and state that in *E. M'Intoshii* they only connect the autozooid cavities with the lacunar system whereas in *E. echinatum* and in *Actinoptilum* they also connect the lacunar system with the median longitudinal canals.

In *E. elongatum* and in *E. minimum* I have found a number of pores or short passages corresponding with these canals (Pl. IV, figs 27 & 28). They are not very numerous but, in my series of sections, I have found them connecting the longitudinal canals with one another (Pl. IV, fig. 28 *p.*), the autozooid cavities with the lacunar system of solenia and the lacunar system with the longitudinal canals. In neither species however can I find the sphincter muscles described by these authors. Both the specimens were excellently preserved and I have examined the passages both in longitudinal and transverse sections but I can find no trace of the muscles described. The epithelium guarding the passage is thickened and characterised by its very darkly stained nuclei which might be mistaken for muscle fibres in transverse section. There can be no doubt that they are ciliated, some of the cilia being preserved in situ in the sections of *E. minimum*.

The relations between the species collected by the Siboga expedition and the two previously known species of the genus require a few words of comment.

Echinoptilum minimum appears to be most closely related to *Echinoptilum M'Intoshii* of Japan in presenting a well marked ventral curvature of the colony, in having the rows of autozooids situated at some considerable distance apart from one another so that their calices do not overlap and in having short calyx teeth. On the other hand *E. M'Intoshii* has a longer stalk and spicules in the tentacles.

Echinoptilum echinatum of KÜKENTHAL agrees with *E. minimum* and differs from all the other "Siboga" species in having a pronounced ventral flexure. It appears to be most closely

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related to *Echinoptilum asperum* but differs from it in having larger and less crowded autozooids and longer calyx teeth, *E. asperum* is also of somewhat stouter build.

As the characters upon which the species of this genus were founded are not very reliable it may be considered premature to propose a key scheme but provisionally the six species may be arranged as follows: —

A. With a pronounced ventral flexure
   1. With spicules in the tentacles and a short broad rachis
      *With small calices . . . . . *E. M'Intoshii*
      **With large calices . . . . . *E. echinatum*
   2. With no spicules in the tentacles and a long narrow rachis . . . *E. minimum.*

B. Without any ventral flexure
   1. With a very long narrow rachis and no spicules in the tentacles. . *E. elongatum*
   2. With a short broad rachis and with spicules in the tentacles
      *With very long spicules . . . . . *E. asperum*
      **With spicules of medium length . . . . . *E. roseum.*

1. *Echinoptilum roseum* n. sp. (Pl. III, fig. 18; Pl. V, fig. 29. Textfigs 10 & 11).

Stat. 251. 5° 28′ S., 130° 0′ E. Off Kei Islands. 204 metres. 1 Ex.

There is only one fine specimen of this species, 142 mm. in total length. It is the largest specimen of the genus that has been found being 12 mm. longer than the largest specimen of *E. echinatum* described by KÜKENTHAL and BROCH.

It is perfectly straight. There is no sign of the ventral bend which these authors describe as a character of the genus. The rachis is sharply marked off from the stalk, being very much wider below than the upper part of the stalk. It is distinctly bilateral, the ventral side being marked by a deep groove, (44 mm. in length) broad below and gradually narrowing above until it is little more than a straight parting between the autozooids. That this is on the ventral side of the rachis is suggested by the fact that the autozooids of the lower rows increase in size from the groove outwards as they do in passing from the ventral to the dorsal side of the leaf in a *Pennatula.*

The autozooids are arranged in rows which are set not quite transversely but inclined at an angle passing downwards from the ventral to the dorsal side. These rows are crowded together, overlap one another and in the distal parts of the rachis become confused. On the dorsal side of the rachis the autozooids being much larger than on the ventral side the rows are more difficult to trace. I have estimated that there are from 20—25 autozooids in each complete row in the circumference of the middle region of the rachis.

The length of the rachis is 80 mm. its greatest breadth at the base is 22.5 mm. It narrows above to a diameter of 10 mm. and then abruptly terminates in a rounded extremity.

The autozooids are protected by well-developed calices and each calyx bears a pair of pointed teeth. In the larger autozooids the calyx body is 5 mm. and each of the teeth about 2 mm. in length. The teeth are rendered rigid by the presence of a large number of red

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rod-like spicules. KÜKENTHAL and BROCH describe the teeth of the calices of *E. echinatum* as "lateral" but my interpretation of them in this species and in the other species of the genus is that they are both ventral or abaxial because the expanded anthocodia is wholly between them and the body of the rachis, and judging from HUBRECHT's figures the same must be true of the type specimen of *E. M'Intoshii*. A few of the autozooids were expanded in the specimen. They show a long and very thin-walled anthocodia with eight long feathery tentacles.

The length of the anthocodiae cannot be determined with accuracy but in the larger forms it is probably not less than 5 mm. The tentacles are supported by axial spicules. There are no spicules in the pinnules.

The siphonozooids are very numerous but not very conspicuous and therefore their general distribution on the rachis cannot be determined. In sections, however, it can be shown that some of the siphonozooids are situated on the bases of the calices of the autozooids and some between them. I have not noticed that any siphonozooids in this specimen have verrucae.

Spicules. The most characteristic spicules are those which are found in the walls of the calices. They are long red needles (fig. 10 p. 59) slightly expanded in the middle and with rounded blunt extremities. The largest of these partially or wholly support the calyx teeth and are 1.0 × 0.05 mm. in size. The spicules in the basal part of the wall of the calyx are of the same form but smaller in size and paler in colour. The surface of the spicules show a few curved ridges which in nearly all cases pass into three prominent flanges at the two ends.

The spicules of the stalk are densely crowded in the superficial layers of the skin. They are of various shapes such as short needles, rods, knobbed rods and disks; but the prodominant forms are rods with rounded ends 0.11 mm. × 0.043 mm. in size (fig. 11 p. 60).

The axis of the tentacles of the autozooids is supported by a crossed row of short knobbed rods 0.2 mm. × 0.05 mm. in size, but there are no spicules in the pinnules.

A thorough examination could not be made of this unique specimen, but no trace of an axis could be felt by probing in the stalk and rachis through a small window cut in the side.

Colour. The general colour of the rachis is roseate in the preserved material. This is due to the long red spicules of the upper parts of the calices which project into the calyx teeth. At the base of the calices the spicules are quite white and transparent. The general surface of the rachis and of the stalk is white or very pale yellow.

The specimen proved to be a male.

The definition of the species founded on a single specimen may provisionally be given as follows: —

Large and fleshy colonies with a conical rachis and a well marked distinction between stalk and rachis. Ventral track in a distinct groove of the rachis. Autozooids very numerous, with long calices overlapping and crowded. Teeth of the larger calices 2 mm. Siphonozooids numerous, without verrucae, situated on the calices of the autozooids and between them.

Spicules of the calices up to 1 mm. in length. Spicules in the tentacles. Spicules very numerous in the cortex of the stalk. Colour of the teeth und upper part of the calices red, of the lower part of the calices pale pink, of the ventral track, of the general surface of the rachis and of the stalk pale yellow. Off Kei islands 204 metres; hard sand.

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2. *Echinoptilum elongatum* n. sp. (Pl. V, figs 30 & 31 and textfigs 10 & 11).

Stat. 318. 6° 36′ S., 114° 55′ E. Java Sea. 88 metres. 4 Ex.

There are four specimens of this species in the collection of which two are much smaller than the others.

The principal measurements of the four specimens are as follows: —

	A	B	C	D
Total length	55 mm.	60 mm.	25.5 mm.	21.5 mm.
Length of rachis. . . .	35 „	42 „	17.5 „	15 „
Length of stalk	20 „	18 „	8 „	6.5 „
Diameter of rachis . .	3 „	2.75 „	2 „	1.75 „

These figures express the principal feature on which the species is founded, namely its elongated and slender shape. The ratio of total length to the maximum diameter of the rachis in A is 18.3 : 1 and in B 21.8 : 1 or twice as much as has been observed in any other species. In the two younger specimens it is 12.7 : 1 and 12.3 : 1 respectively, a proportion not so great as it is in the older ones but nevertheless greater than in any other species. Another feature that may be observed in all the specimens is that there is no sudden constriction in the diameter at the boundary between the rachis and the stalk. The difference between the maximum diameter of the rachis and the minimum diameter of the stalk (apart from the pointed extremity) is only 0.5 mm.

There is no pronounced ventral flexure of the colony as a whole.

The rachis is (in A and B) about twice the length of the stalk and bears a few large autozooids and a considerable number of much smaller ones. The arrangement of these autozooids in transverse rows is obscure over the greater part of the rachis, but at a distance of from 5 to 6 mm. from the stalk where small autozooids only are seen the arrangement in rows is more pronounced. There are not more than four or five large autozooids in any complete encircling row in the middle region of the rachis and not more than seven or eight small autozooids in such a row in the lower part of the rachis.

The shape of the rachis in all the specimens is nearly cylindrical terminating distally in a rounded extremity. In B there is a slight swelling just below the distal extremity. The ventral track is not very well developed but it can be clearly traced for a distance of 12 mm. in A and 15 mm. in B.

The autozooids appear to be in various stages of growth even in the largest specimens. In the largest the calyx is 4 mm. in length and about 2 mm. in diameter, with calyx teeth 1.3 mm. in length. At the lower end of the rachis the autozooids are much smaller but the calices bear small teeth armed with spicules as in the larger ones above. In the upper part of the rachis there are a few large autozooids which considerably overlap one another and between them numerous small colourless papillae many of which show a pair of tooth-like processes and a minute perforation. The question to be determined is whether these "rudimentary calices" are the calices of small autozooids or of siphonozooids, and the conclusion I have come to is that they should be classified as autozooids (vide infra "siphonozooids").

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Many of the anthocodiae of the large autozooids are fully expanded and are 5 mm. in length. The tentacles are long and pinnate but without any support of spicules. The body wall of the anthocodia is thicker and more opaque than in *E. roseum*.

Siphonozooids. A single series of sections made through one of these specimens seems to show that there are very few siphonozooids and that they are quite sporadic.

My sections pass through several young and small autozooids and the siphonozooids do not appear to be more numerous than the autozooids.

There is no difficulty in distinguishing between the autozooids and siphonozooids. In the latter there is a stomodaeum with a strong straight siphonoglyph, supported by eight delicate mesenteries and usually a well marked pair of dorsal mesenteric filaments but no tentacles. In the young autozooids the stomodaeum is plaited and there is apparently no true siphonoglyph. Tentacles may or may not be developèd. There are eight mesenteries but the mesenteric filaments are either undeveloped or smaller in size than the pair of dorsal mesenteric filaments of the siphonozooids.

In the sections of the young autozooids the calyx walls can be clearly seen, and in some cases very minute papillae on each side of the mouth of the siphonozooids can also be seen but it is impossible to say for certain whether these minute papillae could be seen in surface view before decalcification.

My impression is that the true siphonozooids cannot be seen at all from the surface but without further investigation I should not like to make that as a dogmatic assertion.

On this point BALSS, in my opinion, is probably correct in asserting that the small zooids on the convex side of the rachis of *E. M'Intoshii* are autozooids. It does not appear to me, however, that he had any satisfactory evidence to prove his statement that the siphonozooids at the apex (Spitze) of the rachis are provided with small calices, but as I have had no opportunity of examining the species he describes it may be the case in *E. M'Intoshii*. In *E. elongatum* many of the small calices at the apex certainly represent young autozooids as a crown of short tentacles can be seen protruding from them.

The stalk of Specimen A is 20 mm. in length. It is directly continuous with the rachis, then gradually narrows to a diameter of 2.5 mm. and expands again below to a diameter of 3 mm. before ending below in a blunt point.

The spicules of the calyx and calyx teeth of the larger autozooids are orange red in colour, similar in shape to those of *E. roseum* but on an average decidedly smaller (fig. 10, p. 59). A few examples in my preparations were 0.71 mm. in length but these seemed to be exceptionally large. The average length of the larger spicules is about 0.6 mm. The colour of the spicules at the base of the large calices and of all the smaller ones are only faintly yellow. On the rachis and stalk they are colourless.

The spicules in the superficial layers of the stalk are mostly needles with the characteristic longitudinal ridges 0.5—0.6 mm. in length and 0.043 mm. in greatest breadth (fig. 11 p. 60). They are longer than the spicules of the stalk of any other species examined but are not so crowded together.

I have examined three expanded anthocodiae and can find no spicules either in the

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tentacles or body wall. Whether this is natural or not cannot be determined. The preservation of the specimens seems to be quite good, but still there is a possibility that they have been rubbed off.

There is no axis.

The colour of the rachis of three of these specimens is in striking contrast to that of the other species being decidedly orange. The fourth specimen is orange red.

The definition of the species based on four specimens may read as follows: —

Slender straight colonies with a cylindrical rachis, the rachis passing into the stalk without contraction in diameter. Autozooids overlapping but not crowded, very variable in size, a few large ones with calices 4 mm. in length, others much smaller. Teeth of the larger calices 1.3 mm. in length.

Siphonozooids few in number without verrucae. No spicules is the tentacles. Spicules in in the cortex of the stalk very long but not crowded. Colour of the calices, general surface of the rachis and ventral track pale orange or orange red. Stalk colourless. Java sea 88 metres. Bottom: fine yellowish-grey mud.

3. *Echinoptilum asperum* n. sp. (Pl. IV, fig. 23 and textfigs 10 & 11).

Stat. 85. 0° 36′ S., 119° 29′ E. W. coast of Celebes. 724 metres. 2 Ex.
Stat. 178. 2° 40′ S., 128° 37′ E. N. coast of Ceram. 835 metres. 1 Ex.

The three specimens of this species were of approximately the same size, shape and colour.

The rachis forms an isosceles triangle with the base much greater than the diameter of the stalk with which it is continuous. The calices are large and very prominent with long pointed teeth and dark red in colour, giving the rachis a very rough spiny appearance. One specimen was quite straight, the others are bent in such a manner as might be produced by rough handling in the dredge or in preservation. There is no evidence of the continuous ventral bend of *E. echinatum* and other species.

The total length of one specimen is 48 mm. The rachis is 32 mm. in length and its greatest diameter is 10 mm. The greatest diameter is close to the base or proximal end and from that region it gradually narrows distally until it ends in a blunt point.

The ventral groove is very pronounced being both longer and broader in proportion to the length of the rachis than it is in the other species. In the specimen measured it was 20 mm. in length.

The autozooids are arranged in horizontal rows of about eight individuals (i. e. 4 on each side). The four on the dorsal side are much larger than those on the ventro-lateral sides and considerably overlap the row above them. The larger calices are 5 mm. in length and almost cylindrical in shape.

Although the rachis of the specimens included in this species is so much shorter than it is in *E. roseum* the teeth of the calices are quite as long. In the largest autozooids they are at least 2 mm. in length. As in the other species they are composed of long red needles converging to a point.

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The siphonozooids are very numerous and are distributed irregularly on the rachis and on the bases of the calices of the larger autozooids as in *E. roseum*. They are however much more clearly seen among their dark red surroundings as minute verrucae with a clear white centre and two very small teeth.

The stalk of the specimen measured is 16 mm. in length with a minimum diameter of 2.5 mm. and a maximum diameter (in the region that may be called the bulb) of 3 mm.

The spicules are red in colour and in the teeth of the calices reach the maximum size of 1.5 mm. × .1 mm. (fig. 10, p. 59). These are the largest spicules I have found in any of the species. The other spicules of the calyx are also of considerable size with an average length of over 1 mm. The long red spicules extend on to all the other parts of the rachis except the base of the ventral groove which is white.

The tentacles of the autozooids are supported by a series of overlapping red spicules of the usual shape. The largest of these are .1 mm. × .014 mm. but they become smaller in size and fewer in number towards the apex of the tentacle. The terminal third of the tentacle and the pinnules are free from spicules. The spicules in the superficial parts of the stalk are not so crowded as in the other species and they are in the form of long, slender red needles 0.157 mm. in length by 0.02 mm. in greatest breadth. In this respect the species seems to be quite distinct (fig. 11, p. 60).

There is no axis.

The colour in this species is in marked contrast to that of the others. The whole of the calices and the general surface of the rachis with the exception of the ventral groove are dark salmon red, the upper third of the groove is sprinkled with red spicules, the lower two thirds is white. The dorsal side of the stalk is orange coloured with the exception of the terminal bulb which is pale yellow fading to white at the extremity. The ventral side of the stalk is much paler than the dorsal side but shows some faint yellow colour.

The specimen examined in sections was a male.

The definition of the species based on 3 specimens from two localities may read as follows:

Robust, straight, echinate colonies of medium size with a conical rachis, and with a very pronounced distinction between stalk and rachis. Autozooids overlapping and crowded. The larger calices 5 mm. in length with large teeth, 2 mm. in length. Siphonozooids numerous provided with small toothed verrucae. Spicules in the tentacles. Spicules in the cortex of the stalk small and not crowded.

Colour of the calices and of the general surface of the rachis dark red. Ventral track and ventral side of the stalk colourless. Dorsal side of the stalk orange. West coast of Celebes 724 metres and North coast of Ceram 835 metres. Fine grey mud and blue mud.

4. *Echinoptilum minimum* n. sp. (Pl. IV, figs 21 & 22; Pl. V, fig. 32 and textfigs 10 & 11).

Stat. 294. 10° 12′ S., 124° 27′ E. S. coast of Timor. 73 metres. 40 Ex.

The forty specimens of this species vary in size from a maximum of 34 mm. to a minimum of about 12 mm.

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Many of them were killed in a state of partial expansion and they all appear to be admirably preserved. With a few exceptions they show a well marked ventral curvature in striking contrast to all the specimens of the other species in the collection.

My first impression was that they were young specimens of *Echinoptilum roseum* but, apart from the ventral bend and other anatomical characters, the difference in habit suggests that it is advisable at present to keep them distinct.

Echinoptilum roseum is a represented by a single specimen obtained on hard coral sand at a depth of 204 metres off the Kei islands, whereas *E minimum* is represented by no less than forty specimens contained in a single haul on soft mud and very fine sand at a depth of 73 metres off the S. coast of Timor. The distance between the two localities is only 140 geographical miles and is not in itself a sufficient reason for making a specific distinction between the two forms; but as the distance is accompanied by a great difference in depth and in the character of the bottom a much more convincing proof than we possess at present is required before their identify can be affirmed.

It is unfortunate that no small forms of *Echinoptilum roseum* were captured in the dredgings off the Kei islands to compare with the smaller specimen of *E. minimum* but it seems probable from a comparison of *E. minimum* with specimens of approximately the same size belonging to the species *E. elongatum*, and *E. M'Intoshii* (HUBRECHT's specimens) that the species is a good one.

The largest specimen in the collection was only 34 mm. in total length, but the average total length of all the specimens in the collection was not more than 25 mm. It is impossible to say from the study of the result of only one sweep of the net however, whether or not the species is characterised by its small size.

In this, the largest, specimen (Pl. IV fig. 21) the rachis was 24 mm. in length with a maximum diameter of 4 mm. The rachis is almost cylindrical in shape for the greater part of its course as in *E. elongatum*, but rather flattened on the ventral side. It gradually narrows to a blunt end distally and passes proximally, without any sharp constriction, into the stalk.

The autozooids are arranged in rows of 6—8 (i. e. 3 or 4 on each side of the rachis). The rows are quite horizontal below but slope downwards from the ventral to the dorsal side above.

The calices are comparatively short, (the largest 2 mm. in length,) and do not overlap.

There are comparatively few rows and the space between the rows is greater than it is in any of the other Siboga species. I have calculated that in the largest specimen there are not more than 80 autozooids arranged in 12 rows. The teeth of the calices are comparatively short, the largest I have measured being only 0.3 mm. in length. The ventral track is well marked but not very long. In the largest specimen it can be traced for a distance of only 5 mm.

The anthocodiae are in many cases protruded but never fully expanded. The tentacles do not bear spicules.

The siphonozooids are very numerous and scattered in an irregular manner between the rows of autozooids and the individual autozooids of a row. They are protected by a well marked but small verruca with two verruca teeth.

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On first examination from the surface I was inclined to believe that as in *E. elongatum* the small calices on the surface represented young autozooids but the series of sections showed on microscopic examination that they are all true siphonozooids. I have found in these sections no single example intermediate in character between an autozooid and a siphonozooid.

The stalk in the largest specimen is 10 mm. in length with a diameter of 3 mm. At the proximal end it is slightly swollen to form a bulb 3.25 mm. in diameter. It has, in this and in nearly all the other specimens a very pronounced ventral flexure.

The spicules of the calices and rachis are of the usual shape the largest being 1 mm. × .042 mm. in size. The average length is about 58 mm. i. e. about the same as *E. elongatum*, but the general impression is that they are a little thicker in *E. minimum* than in *E. elongatum*.

There are no spicules in the tentacles or body walls of the anthocodiae. The spicules of the superficial parts of the stalk are 0.343 × 0.04 mm.

There is no axis.

The colour of the specimens of this species shows some variation but the characteristic features appear to be these. The calices of the autozooids are red or orange in colour, the points of the teeth colourless. The verrucae of the siphonozooids are invariably colourless. The general surface of the rachis between the calices varies in colour from white, pale orange-red or red to uniform dark red.

The ventral track and the stalk are always colourless. The single specimen cut in sections proved to be a female and as some of the oocytes contain a considerable amount of yolk, it seems probable that they are approaching maturity. The largest eggs measured were 0.075 mm. in diameter, with a germinal vesicle 0.035 mm. in diameter bearing a single chromatin body 0.005 mm. in diameter.

The definition of the species based on 40 specimens may read as follows: —

Small rather slender curved colonies with a cylindrical rachis, the rachis passing into the stalk without any marked diminution in diameter.

Autozooids not very numerous and not overlapping. Calices comparatively short, not exceeding 2 mm. in length. Siphonozooids numerous, provided with small but well marked verrucae and teeth. Teeth of the calices very short. Spicules of the larger calices 1 mm. in length. No spicules in the tentacles. Spicules of the cortex of the stalk large and crowded. Colour of the calices red or orange. Ventral track and stalk colourless. The general surface of the rachis variable in colour. S. coast of Timor 73 metres. Fine mud.

Family Kophobelemnonidae Gray.

Kophobelemnonieae Kölliker 1872. Die Pennatuliden. p. 296.
Kophobelemnonidae Kölliker 1880. "Challenger" Pennatulida. Vol. I, p. 16.

This family corresponds with the family Kophobelemnonieae of Kölliker (1872 p. 296) and the Kophobelemnonidae of Kükenthal and Broch (1911 p. 215).

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Five genera have been assigned to the family but, of these, three should be suppressed leaving only the two genera *Kophobelemnon* and *Sclerobelemnon*. *Bathyptilum* (Köll. 1872 p. 378) and *Gunneria* (K. & D. 1884 p. 58) are clearly species of *Kophobelemnon* and *Mesobelemnon* (Gravier 1908 p. 228) is a species of *Sclerobelemnon* (see p. 79).

The family is most closely related to the Veretillidae as shown more particularly in some of the varieties of *Sclerobelemnon Burgeri* but it shows the beginning of bilateral symmetry in the presence of a track on the dorsal side of the rachis that is free from autozooids and the lower part of this track is also, usually, free from siphonozooids.

Of the two genera *Sclerobelemnon* is the more generalised, *Kophobelemnon* the more specialised.

In *Sclerobelemnon Burgeri* we find, even in specimens from the same locality, a similar extreme variability, as regards the number, shape and size of the spicules, to that we find in some of the species of the Veretillidae. In some specimens of this species even the trace of bilateral symmetry is lost and the zooids appear to be distributed evenly all round the rachis. Its spicules, although extremely variable, are always thin flat plates and in that respect resemble the spicules of the species of *Veretillum*. So similar are these spicules that I do not think it would be possible even for an expert to be certain that a given preparation of spicules was taken from a *Veretillum* of from a *Sclerobelemnon*. *Scl. Burgeri* is therefore a link connecting these two genera and at the same time the two families.

Speaking in more general terms, the family is characterised by the autozooids being irregularly distributed or arranged in indistinct longitudinal rows on the rachis. As compared with the Veretillidae the autozooids are usually large in size and few in number and with some rare exceptions (*Scl. Burgeri*) do not occur on the mid-dorsal track. The siphonozooids are very variable in number and distribution but there is usually a short mid-dorsal track at the lower end of the rachis that is free from them. The spicules are flat plates or rods (in *Sclerobelemnon*) or ridged needles (in *Kophobelemnon*). A well developed axis is present in all species.

Sclerobelemnon may be regarded as a shallow water genus, as nearly all the specimens known to Science have been obtained in water of less than 100 metres depth, *Scl. magniflorum* however was found in 472 metres. *Kophobelemnon* on the other hand may be regarded as a deep sea genus, most of the specimens having been obtained in depths of over 300 metres and some of them in very deep water.

The two genera are not easily separated by a single distinct character, and there can be no doubt that they are closely related and overlap in some particulars. I have given reasons however on p. 77 for keeping them distinct.

In the great majority of cases the genera may be distinguished by the characters given below: —

A. With ridged rod-shaped spicules, and with spicules in the tentacles . . *Kophobelemnon.*
B. Spicules of various kinds but when rod-shaped not ridged. Usually no spicules in the tentacles . . . . . *Sclerobelemnon.*

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Genus **Kophobelemnon** Asbjörnsen.

Kophobelemnon Asbjörnsen. Faun. Litt. Norweg. 1856. II, p. 81.
Kophobelemnon + *Bathyptilum* Kölliker. Die Pennatuliden. 1872, p, 296.
Gunneria Koren & Danielssen. Norwegian N. Atlantic Exped. 1884, p. 58.
Kophobelemnon Kükenthal & Broch. Valdivia Pennatulacea, 1911, p. 219.

This genus was first described by Asbjörnsen in 1856. It has more recently been subject to detailed analysis by Jungersen (1904) who united under the name *K. stelliferum* a considerable number of species previously regarded as distinct. The process of amalgamation of species was continued by Kükenthal and Broch and at the time of the publication of their monograph they recognised only three species.

These three species are, 1. the widely distributed and variable *K. stelliferum* (O. F. Müller 1788) of the North Atlantic and Pacific Oceans. 2. *K. heterospinosum* Kükenthal from the W. coast of Sumatra, and 3. *K. affine* Studer from Japan and Panama. To these species must now be added a fourth species *K. hispidum* described by Nutting (1912) from Japan and a fifth *K. pauciflorum* from the Malay archipelago.

Our knowledge of *K. heterospinosum*, *K. affine* and *K. hispidum* is still very incomplete; *K. heterospinosum* is represented by a single very large specimen of which an admirable and detailed description is given by Kükenthal and Broch (1911, p. 220).

It would be interesting to know, however, if smaller specimens from the same locality would justify its separation as a distinct species.

The Panama specimen of *K. affine* was briefly described by Studer (1894 p. 57) but a more detailed account of the single Japanese specimen was given by Kükenthal and Broch. The latter was only 82 mm. in total length and may show some features of juvenility.

Nutting's species *K. hispidum* was also founded (1912) on a single specimen but the author thinks it may be identical with a specimen previously described by him as *Umbellula sp.* from Hawaii.

The specimens belonging to the genus *Kophobelemnon* collected by the Siboga expedition in the Malay archipelago appear to differ from previously described species by the small number of autozooids and by other characters and I regard them as constituting a distinct species *K. pauciflorum*, but it is quite possible that as our knowledge increases it may be found necessary to amalgamate all the species of the genus and to regard *K. pauciflorum* as a local variety.

A provisional arrangement of the species may be made as follows:

A. With two kinds of siphonozooids protected by well-defined verrucae.
   a. With spindle-shaped spicules in the cortex of the stalk . . . . *K. heterospinosum*
   b. With broad rod-shaped spicules in the cortex of the stalk . . . *K. stelliferum*
B. With one kind of siphonozooids without verrucae or with very rudimentary verrucae.
   a. With spindle-shaped spicules in the stalk. . . . . *K. pauciflorum*
   b. With rod-shaped spicules in the stalk . . . . . *K. affine*
C. With spicules up to 1 mm. in length in the rachis? . . . . . *K. hispidum*

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Kophobelemnon may be regarded as a deep sea Pennatulid. *K. affine* has been found at a depth of only 23 metres and some specimens of *K. stelliferum* [1]) from the W. coast of Norway have been found in 36 metres but most of the specimens that have been obtained occurred in depths of over 300 metres.

1. *Kophobelemnon pauciflorum* n. sp. (Pl. II, fig. 13 and textfigs 12—17).

Stat. 5. 7° 46′ S., 114° 30′ E. Bali sea. 330 metres. 1 Ex. (Juv.).
Stat. 85. 0° 36′ S., 119° 29′ E. W. Celebes. 724 meters. 1 Ex.
Stat. 137. 0° 23′ N., 127° 29′ E. near Halmaheira. 472 metres. 22 Ex. + 1 Juv.
Stat. 271. 5° 46′ S., 134° 0′ E. Aru islands. 1788 metres. 4 Ex.
Stat. 300. 10° 48′ S., 134° 23′ E. Rotti. 918 metres. 1 Ex.

The thirty specimens belonging to the genus *Kophobelemnon* collected by the Siboga expedition were all obtained in deep water, close to the coast line from a muddy bottom.

They are all very badly contracted, many of them are broken, so that the axis protrudes, and most of them have the appearance of having been burst and rubbed by the weight of the mud in the net.

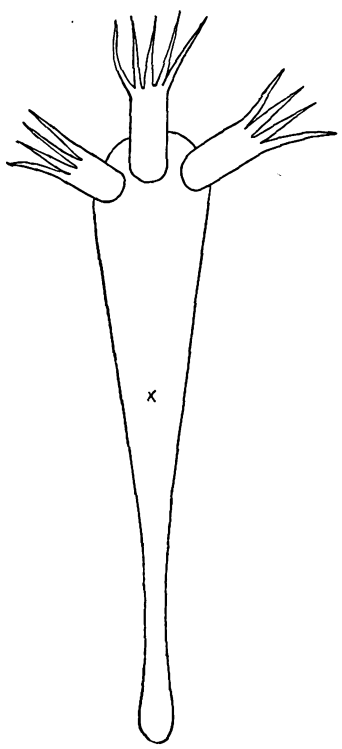

Fig. 12.
Kophobelemnon pauciflorum.
Ventral view of one of the ordinary forms. The × marks the boundary of the stalk and rachis. Nat size.

Under these circumstances it is difficult to determine with accuracy some of the important measurements.

Two specimens from Stat. 137 have a different appearance from the others and were considered, at first to represent a distinct species. These will be described separately. The others, all clearly belonging to a single species, agree in certain characters which separate them from all known species.

The more important of these characters are:

1. The small number of autozooids, arranged subterminally in a single transverse row and 2. the absence of definite verrucae for the siphonozooids (fig. 12).

They vary from 105 mm. down to 10 mm. in length and the greatest number of autozooids in any one specimen is 5. (The two exceptional specimens described on p. have 10 and 12 autozooids respectively).

The colony is club shaped terminating distally is a rounded prominence and proximally in a thin walled bulbous expansion.

The autozooids are arranged in a transverse row a few millimetres below the distal extremity and none of them are retracted below the surface of the rachis. The row is not always quite regular (fig. 12) but there are no large or small autozooids at a distance above or below it.

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1) *Kophobelemnon stelliferum* is now considered to include: —

K. Mülleri Asb.
K. Leuckarti Köll.
K. Möbii K. and D.
K. scabrum Verrill
K. tenue Verrill.
K. abyssorum K. and D.
Gunneria borealis K. and D.
K. ferrugineum Köll.

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The siphonozooids distal to the row of autozooids are situated on shallow verruca-like mounds but on the proximal side of the row these mounds become very shallow and further down the rachis disappear altogether so that the presence of siphonozooids cannot be determined by surface examination.

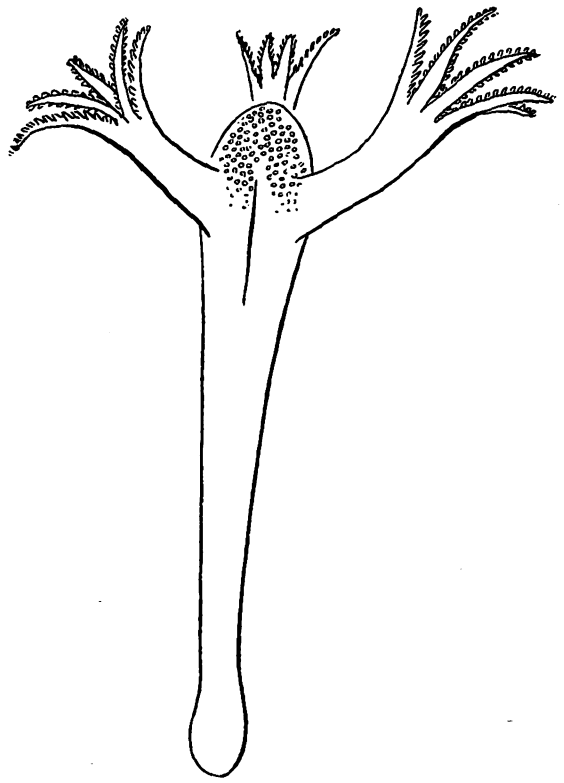

Fig. 13. *Kophobelemnon pauciflorum.*
Dorsal view of one of the ordinary forms. Nat. size.

The stalk is cylindrical in the best preserved specimens but deeply grooved in all the others and terminates in a thin-walled but easily ruptured basal bulb about 10 mm. in length.

The spicules are scattered in great numbers throughout the cortex of the rachis and stalk. They form a feltwork on the body wall of the autozooids, and extend on to the axis and pinnules of the tentacles. They have the form of spindles marked with longitudinal ridges terminating in rounded or jagged ends. In the larger specimens they are about 0.3 mm. in length × 0.03 mm. in breadth in the rachis and about 0.2 mm. in length × 0.03 mm. in breadth in the stalk (Figs 15, 16, 17).

The following figures show the variation in the number of the autozooids in some of the specimens: —

Total length	105 mm.	90 mm.	88 mm.	65 mm.	43 mm.	35 mm.	10 mm.
Number of autozooids .	5	4	4	3	2	3	1

In the largest of the specimens, four of the autozooids were at exactly the same level but one was a little below the row on the mid ventral surface. There is a space free from autozooids on the dorsal side in this, as in all the other specimens, so that the autozooids never form a complete circle round the rachis.

The body of the autozooid in this specimen is 7 mm. in diameter, 11 mm. in length and the tentacles are also 11 mm. in length. It is very difficult to determine what relation these figures bear to the length and breadth of the living autozooid but it seems to be certain that the tentacles have some power of contractility and that the autozooids are not completely retractile. The number of pinnules on the tentacles varies with the size of the autozooids, but in the larger ones there are 17 on each side. As an example of the difficulty of estimating the length of the autozooids in this species reference may be made to one specimen from Station 271, 60 mm. in length, which has only one autozooid. In this autozooid the body length is 10 mm. and the tentacles 17 mm. in length, but it shows none of the usual signs of contraction. In the smaller specimens the autozooids are relatively smaller but in all, except the one referred to above, the length of the tentacles is about the same as the body length in the preserved state.

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The exact distribution of the siphonozooids is very difficult to determine owing to the loss of the verrucae in the lower part of the rachis and I have found it quite impossible to determine from surface examination where the rachis ends and the stalk begins. In the largest specimen there appears to be no median space either on the dorsal or ventral side that is free from siphonozooids but in some of the smaller forms there is a short free track on the ventral side and a longer one on the dorsal side.

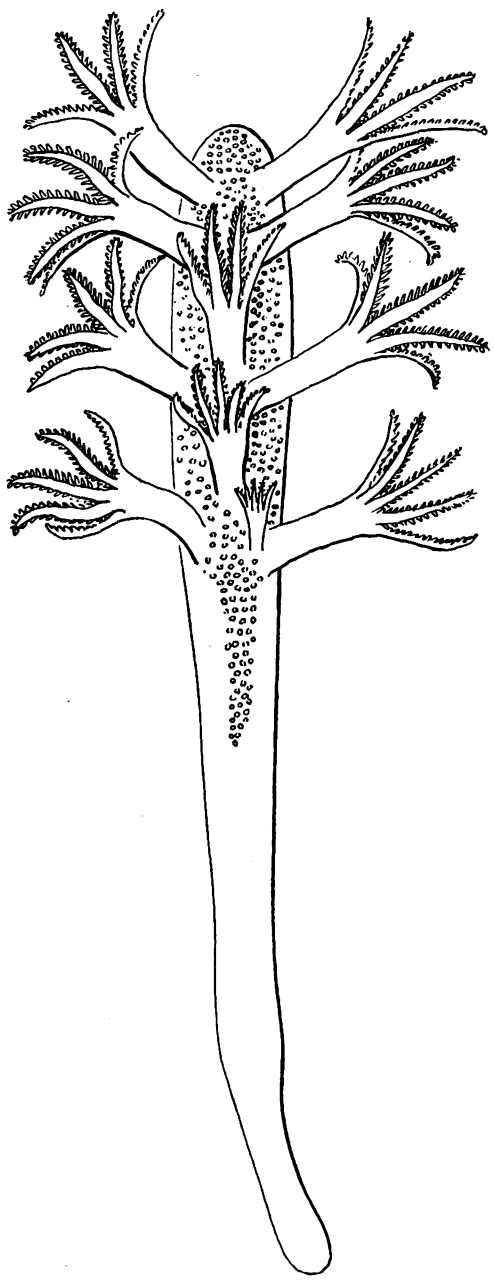

Fig. 14. *Kophobelemnon pauciflorum.* Ventral view of one of the extraordinary forms. Nat. size.

In order to determine, if possible, the ratio of rachis length to length of stalk I made a series of preparations cleared in oil for examination with the microscope and found that siphonozooids are present even where no trace of them can be seen by surface examination with high powers. It would be, therefore, a guess, worse than useless, if I were to attempt to give the ratio for all the 28 specimens.

As regards the verrucae of the siphonozooids. In the upper part of the rachis above the row of autozooids, the verrucae are supported by a cluster of spicules of the rachis of the ordinary type, but these spicules do not show any special arrangement, fan-wise or more regularly parallel, as figured by KÜKENTHAL and BROCH for *K. heterospinosum* and *K. stelliferum*. It is for this reason that the statement is made above that there are no true verrucae (or calices) in this species. In the lower part of the rachis the siphonozooids are marked simply by irregular openings in the crowd of surface spicules.

The siphonozooids increase in size from the distal to the proximal end of the rachis but cannot, satisfactorily, be divided into two sets. In a single series of sections through the cortex of the middle region of the rachis the stomodaeum of the siphonozooids was 0.1 mm. in length, with a well developed siphonoglyph and two dorsal mesenteric filaments.

The spicules are very variable in size in different specimens. I have examined spicules from several specimens and the figures given above (0.3 × 0.03 mm.) represent approximately the measurements of spicules in a specimen 100 mm. in length. In a specimen of the same length I have found the spicules of the body wall of the autozooid to be 0.25 mm. in length and of the tentacles 0.28 mm. in length.

In every preparation the length of the spicules varies considerably, there are always some longer and some shorter than the great majority. In my preparations I have usually

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found that the spicules of the rachis have smooth rounded ends, the spicules of the autozooids jagged or tuberculated ends, but in the younger specimens all the spicules have jagged ends. My impression is that the jagged ends simply indicate that the spicules are in a state of active growth in length.

The spicules of the stalk are much more variable both in length and breadth. They are also very variable in the degree of tuberculation of the ridges. I may mention that in none of my preparations are found any of the double-club shaped spicules such as were figured by KÜKENTHAL and BROCH for *K. affine*.

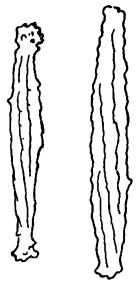

Fig. 16.
Kophobelemnon pauciflorum.
Spicules of the tentacles.
× 120 diam.

The two exceptional specimens referred to on p. 72 are 140 mm. and 103 mm. respectively in length. In both of them the autozooids are more numerous and more widely distributed over the rachis than in any of the specimens of the other type.

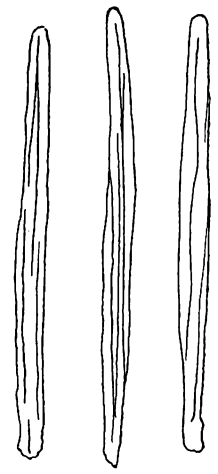

Fig. 15.
Kophobelemnon pauciflorum.
Spicules of the rachis.
× 200 diam.

In the larger of the two the arrangement of the autozooids is as shown in text fig. 14. There are 12 autozooids in all, two are situated laterally at the same level about 3 mm. below the distal extremity another pair also situated laterally about 5 mm. below the first pair, then a single autozooid situated in the mid-ventral line followed by another lateral pair and another mid-ventral single autozooid. Following this single autozooid there are four much smaller autozooids situated more irregularly, two are lateral but not at the same level, one ventro-lateral and another very small and one dorso-lateral.

In this rachis, therefore, there appears to be no definite arrangement of the autozooids either in transverse or longitudinal rows.

In the second specimen the autozooids have a similar irregular distribution extending over an area 40 mm. in length on the ventral and lateral sides of the rachis.

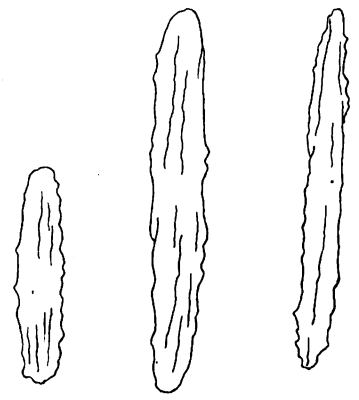

Fig. 17. *Kophobelemnon pauciflorum.*
Spicules of the stalk. × 190 diam.

In both specimens the largest autozooids, at the distal end of the rachis, are 5 mm. in diameter with a body length of about 10 mm. and tentacles up to 12 mm. in length. In the lower part they are smaller and the smallest are not more than 1 mm. in diameter.

The siphonozooids are similar to those of the other type but more clearly marked. At the proximal end of the rachis there is a dorsal track free from siphonozooids and probably a ventral one also but the difficulty of determining the absence of siphonozooids is no less in these than in the other specimens.

My estimate of the length of this rachis from careful surface examination is, in the case of the larger specimen (140 mm. in total length) 70 mm. and of the smaller specimen (103 mm. in total length) 60 mm.

The spicules are of the same type as those of the other specimens but in the larger

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specimen they are rather larger reaching a maximum in the rachis of 0.5 mm. × 0.04 mm. The distribution of the spicules in the rachis, stalk and autozooids is the same and, judging from the spicules alone, there can be no doubt that these two extraordinary forms belong to the same species as the others.

The very small specimen (10 mm. in total length) (Plate II, fig. 13) is very similar to the figure given by KÖLLIKER (1880 Pl. XI, fig. 44) of *Kophobelemnon sp.* from 700 fms. off the coast of New Zealand and to the figures given by GRIEG (1893 Pl. II, figs 42 and 43) of specimens, 6 mm. and 22 mm. in length, of *Kophobelemnon stelliferum.* It has only one autozooid and the spicules of the rachis do not exceed 0.2 mm. in length.

There can be little doubt that all the specimens of this genus that were collected by the Siboga Expedition belong to the same species.

The two extraordinary forms, twenty ordinary forms and the very small one described above all came from the same locality, the spicules, although varying in size according to the sizes of the specimen, are of the same type and have the same distribution; but they afford an interesting example of the danger of determining species by the study of a single specimen.

If the smaller of the two extraordinary specimens and the largest of the ordinary type had been the only specimens in the collection I should have been inclined to place them in separate species as their general appearance is so different and the smaller specimen has the larger number of autozooids.

A specimen from Station 300 however 75 mm. in length with 3 large autozooids and one small one situated irregularly on the rachis is intermediate in character between the two types as regards the most striking character of difference between them.

As the most obvious character of the new species is the small number of autozooids, the following comparison of specimens in this respect may be useful.

	K. pauciflorum		*K. stelliferum*				*K. affine*	
N°	1	2	3	4	5	6	7	8
Total length in mm.	140	105	158	103	82	106	82	113
Number of autozooids . . .	11	5	27	12	18	22	6	9

The specimen 1 of *K. pauciflorum* in this list has an exceptionally large number of autozooids and does not in any respect represent the average. Judging from the specimens examined N° 2 represents a more typical condition, but even the exceptional form has a smaller number of autozooids in proportion to its size than any specimen of *K. stelliferum*. The figures given for N^os^ 3 & 4 of *K. stelliferum* are taken from KÜKENTHAL and BROCH (1911), for 5 from MILNES MARSHALL (1883) and for 6 from KÖLLIKER (1872).

Only one specimen of *K. affine* (7) has been fully described (by K. and B.) and in that the number appears to be greater than in *K. pauciflorum*. STUDER's specimen (8) had only a few autozooids in relation to its length.

It is difficult to compare the species with *K. heterospinosum* (KÜKENTHAL) from W. Sumatra as the only specimen of that species is 335 mm. in length and has a large number of autozooids.

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In this character the new species is similar, apparently, to NUTTING's *K. hispidum*, of which the only known specimen is 78 mm. in length and has three autozooids.

K. heterospinosum differs from the new species in having completely retractile autozooids and a well marked verruca for the siphonozooids but agrees with it in having a predominance of spindle shaped spicules in the cortex of the stalk.

K. affine approaches the new species in having only very rudimentary verrucae for the siphonozooids but appears to differ from it in the greater number of short tuberculated rods in the cortex of the stalk.

NUTTING's description of *K. hispidum* is not very detailed but if his statement that "The spicules are seldom over 1 mm. in length" may be taken to mean that they are sometimes or frequently as large as 1 mm. in length, his species differ from other Kophobelemnons in the great size of the spicules.

The new species may be defined as follows: —

The colony is club shaped with a small number of non-retractile autozooids usually arranged in a single subterminal transverse row. Siphonozooids irregularly distributed over the rachis, of one kind only and not provided with a definite verruca.

Spicules of the rachis, spindle-shaped and about 0.3 mm. in length in specimens of 100 mm. total length. Spicules of the stalk spindle-shaped and about 0.2 mm. in length.

Malay archipelago 330—1788 metres.

Genus **Sclerobelemnon** Kölliker.

Sclerobelemnon Kölliker. Die Pennatuliden. 1872, p. 309.
Sclerobelemnon Thomson and Henderson "Investigator" Alcyonaria. 1906, p. 89.
Mesobelemnon Gravier. Alcyonaires de Tadjourah. 1908, p. 228.
Kophobelemnon (ex parte) Thomson and Simpson. "Investigator" Alcyonaria. 1909, p. 279.
Sclerobelemnon Balss. Japanische Pennatuliden. 1910, p. 24.
Sclerobelemnon + *Mesobelemnon* Kükenthal and Broch. "Valdivia" Pennatulacea. 1911, p. 217.

This genus was found in 1872 by KÖLLIKER for a specimen from Formosa in the Museum Godeffroy at Hamburg.

The principal points of difference between *Sclerobelemnon* and *Kophobelemnon* according to his definitions, were that the colony of *Sclerobelemnon* was cylindrical (not club shaped) that there were no spicules in the tentacles and that the spicules were "bisquitförmige platte, eckige und stachelige Platten".

He pointed out that his new genus is closely related to *Kophobelemnon Burgeri* from Japan. But in his account of the Challenger Pennatulids (1880) he referred two specimens found in 95—100 fathoms off the Phillipines to the species *K. Burgeri* without further comment on its affinities.

In 1906 (2. p. 88) THOMSON and HENDERSON referred a specimen from the Indian Ocean to the species *K. Burgeri*, var. *indica* which possessed spicules in the tentacles, and eight broad bands of spicules in the body wall of the anthocodiae.

In 1909 THOMSON and SIMPSON described a new species, *K. intermedium*, from the Gulf

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of Martaban (96.9 metres) which appears to be intermediate in some respects between the two genera. This species has no spicules in the anthocodiae of the autozooids.

BALSS (1910 p. 27) definitely referred *Kophobelemnon Burgeri* to the genus *Sclerobelemnon* and described several specimens from 137 mm. in length downward from Japanese waters. He stated that in these specimens spicules do occasionally occur in the tentacles.

The type species of Sclerobelemnon (*Sc. Schmeltzii*) possesses the characters of the genus mentioned above and differs from *K. Burgeri* in having the autozooids arranged in 10—12 longitudinal rows on each side of the rachis instead of in only 3 or 4 rows. Only one other specimen has been referred to this species, namely by BALSS (1910, p. 30).

There can be no doubt that the specimens named *Sclerobelemnon Schmeltzii* are sufficiently distinct from *Kophobelemnon* to constitute a separate genus.

The difficulty is to determine what should be done with the specimens referred to *K. Burgeri.*

The description and the figure given by HERKLOTS of the type specimen of this species suggest very forcibly that it should now be transferred to the genus *Sclerobelemnon.* The single specimen described by KÖLLIKER in 1872 is also, probably, a *Sclerobelemnon.* The specimens collected by the "Challenger" expedition appear to me to occupy a more doubtful position; there is no detailed description of the spicules or zooids and judging from the figures, only, they resemble more closely the young Sclerobelemnons in the Siboga collection than the young Kophobelemnons. This I have confirmed by an examination of the specimens in the British Museum. BALSS' specimens were undoubtedly correctly referred to *Sclerobelemnon Burgeri* and his careful description clearly proves that the species is a very variable one.

THOMSON and HENDERSON's *K. Burgeri*, var. *indica* appears to be more closely related to *Sclerobelemnon* than to *Kophobelemnon*, but the presence of spicules in the tentacles and the description of the spicules as "rods, hour-glass and cruciform" leaves some doubt as to whether they have or have not the thin flattened aspect characteristic of the spicules of the genus *Sclerobelemnon.*

Kophobelemnon intermedium Thomson and Simpson (1909, p. 277) from the gulf of Martaban 96.9 metres does appear to be intermediate between the two genera but on the whole more closely related to *Sclerobelemnon* than to *Kophobelemnon.*

It approaches *Kophobelemnon* in the small number of the rows of autozooids and in the spindle-shaped spicules, and *Sclerobelemnon* in the absence of spicules in the body walls and tentacles of the autozooids. If the spicules are not ridged or 3-flanged there could be no hesitation in placing it with *Sclerobelemnon* but on this point there is no information.

THOMSON and SIMPSON (1909, p. 279) suggested that the genera *Kophobelemnon* and *Sclerobelemnon* should be merged on the ground that their species *K. intermedium* forms a connecting link between them.

Apart from the specimen on which this species was founded however the two genera appear to me so far distinct that it would be inconvenient to merge them together.

The rod-shaped and ridged spicules that occur regularly in the rachis of all the specimens of *Kophobelemnon* I have examined form a very distinctive character when compared with the flat plate-like spicules of *Sclerobelemnon.*

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It is true that rod-shaped spicules do occur amongst the great variety of spicules found in the species of *Sclerobelemnon* and that occasionally they show a shallow ridge (*Sc. Gravieri* p. 89) but the thin plates twins and quadruplets never occur in any specimens of *Kophobelemnon* so far as my experience goes.

The presence of spicules in the anthocodiae of *Kophobelemnon* is clearly a character which is not absolutely reliable as a distinction from *Sclerobelemnon* for BALSS and THOMSON and HENDERSON have shown that spicules do occasionally occur in this position in a species that should be attributed to the genus *Sclerobelemnon.*

Although I have not found any spicules above the base of the anthocodiae in any specimen of the many Sclerobelemnons I have examined the great variability of the species as regards their spicular armament suggests that more exceptional cases of this kind may be recorded.. But in the great majority of cases the absence of spicules in the anthocodiae is a very striking feature of *Sclerobelemnon* as compared with *Kophobelemnon.*

The great size and small number of autozooids in the rachis of *Kophobelemnon* is another character which, in a general way. separates it from *Sclerobelemnon.* This difference however is one that it is difficult to define in the larger specimens as the size and number of the autozooids varies with the age. The difference however, between a young *Kophobelemnon* and a young *Sclerobelemnon* of a length of 18 mm. or less is very striking and no one would suggest that they belong to the same genus. In the former there is one large subterminal autozooid visible on the surface and in the latter there are six or seven small autozooids on each side of the rachis (see p. 87, and Plate II, figs 13 & 14).

In 1908, GRAVIER established a new genus called *Mesobelemnon* upon a single specimen 40 mm. in length obtained in shallow water in the Red Sea. The description of the species (*M. gracile*) is very detailed and well illustrated so that it is not difficult to compare it with the species of *Sclerobelemnon.*

The general superficial appearance of this species is very similar to that of several specimens of *Sclerobelemnon Burgeri* in the Siboga collection but it differs from this species in having a special grouping of spicules around the siphonozooids and the base of the anthocodiae of the autozooids forming in the incompletely retracted colony rudimentary verrucae; in the small number of siphonozooids; in the form of the spicules and in some other respects.

In their discussion of the position of this species KÜKENTHAL and BROCH (1911 p. 217) express their opinion that the genus is a good one and that a very important distinction of the genus is the remarkable shape of the spicules.

The original description and the excellent figures show that the spicules have various shapes but that a form of flattened rod-shaped spicule with bifurcated extremities which has been called "bone-shaped" is prevalent.

This peculiar form of spicule does occur exceptionally in the species of *Sclerobelemnon* that I have examined and particularly in one specimen of *Sclerobelemnon elongatum* but the other spicules that occur in *Mesobelemnon gracile* are frequently found and sometimes in great numbers in *Sclerobelemnon Burgeri* and other species of that genus. In view of the remarkable variations in the shape and size of the spicules of the genus it is clear that the presence

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of "bone shaped" spicules would be a character of very little importance in justification of the retention of the *Mesobelemnon* as a distinct genus.

The very irregular distribution of the autozooids on the rachis is a character that it shares with some, but not all, of the specimens of *Sc. Burgeri* in the Siboga collection.

As regards the character that the siphonozooids are few in number ("les siphonozooides en nombre restreint") my studies suggest that it is a character that is liable to a good deal of variation and not one that can be relied on for the establishment of a genus or species unless several specimens have been examined and the character found to be constant. I have found a great variability in the relative number of siphonozooids in all species of *Sclerobelemnon* but particularly in *Sc. Burgeri* and *Sc. elongatum*. In some of the specimens of the latter species there are very few siphonozooids — not more than are figured for a given area in *Mesobelemnon gracile* — in others however they are much more numerous. It is a curious point of similarity that in the specimens of *Sc. elongatum* with few siphonozooids these structures are marked by chocolate-coloured patches corresponding with the light brown patches that mark the siphonozooids of *Mesobelemnon*.

In conclusion I must state my opinion that the further study of the variations of the genus *Sclerobelemnon* shows that *Mesobelemnon* can no longer be maintained as a distinct genus. I write this with regret as the excellent and detailed account of the specimen by GRAVIER deserves a better fate. The species may remain, however, as a distinct species of *Sclerobelemnon* (*Sc. gracile*). It appears to me to have close affinities with *Sc. Burgeri* and that when more and larger specimens are examined these affinities will be emphasised, but, bearing in mind its wide geographical separation from the known specimens of *Sclerobelemnon Burgeri* and the physical conditions of the shallow water of the Red Sea it is quite probable that it is quite distinct.

The species of the genus may for convenience be arranged in the following plan but it must be said that the proximity of *Sc. elongatum* and *Sc. magniflorum* in the plan does not signify genetic affinity.

A. With 7—10 longitudinal rows of autozooids on each side of the rachis . . . . . *Sc. Schmeltzii* (Köll.)

B. With 2—4 rows of autozooids on each side of the rachis. (The rows usually very irregular)
   a. With bone-shaped spicules prevalent in the rachis . *Sc. gracile* (Gravier)
   b. With bone-shaped spicules rare in the rachis . . *Sc. Burgeri* (Köll.)

C. With 1—2 rows of autozooids on each side of the rachis
   a. Autozooids with verrucae (pseudocalices)
      1. With a cylindrical axis . . . . . *Sc. Gravieri* n. sp.
      2. With a quadrangular axis . . . . . *Sc. intermedium* (Thom. & Simp.)
   b. Autozooids without verrucae (pseudocalices)
      1. With long slender rachis and small autozooids *Sc. elongatum* n. sp.
      2. With short rachis and large autozooids . . . *Sc. magniflorum* n. sp.

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To this list of species must be added two others each founded on the investigation of a single specimen and of doubtful value unless confirmed by subsequent researches.

Sclerobelemnon Köllikeri (Thom. and Hend. 1906 (2)) with very few small spicules and *Sclerobelemnon indicum* = *K. Burgeri*, var. *indica* Thom. and Hend. 1906 (2) with a rich armature of spicules in the tentacles and body wall of the anthocodiae of the autozooids. Both these species have autozooid verrucae (pseudocalices).

Distribution. The genus *Sclerobelemnon Schmeltzii* (Kölliker 1872, p. 313) occurs off Formosa and according to the research of THOMSON and MACKINNON (1911, p. 693) and of BRIGGS (1915, p. 91) also off the coast of New South Wales in 40 to 110 metres of water. *Sc. Burgeri* extends from the Malay Archipelago northwards to Japan and westwards to the Indian Ocean. It is found in depths of 20 to 180 metres.

Sclerobelemnon gracile was found by GRAVIER (1908, p. 228) in shallow water in the Red Sea. *Sclerobelemnon Köllikeri* of THOMSON and HENDERSON was found in depths of 124 to 270 metres in the Indian Ocean, but our new species *Sclerobelemnon magniflorum* from Halmaheira was dredged in the greatest depth, namely 472 metres, in which any specimen of the genus has yet been found. It is worthy of note that the species and specimens found in the greater depths of these localities show the greater affinities to the typically deep sea genus *Kophobelemnon*.

1. *Sclerobelemnon Burgeri* Herklots. (Pl. I, fig. 3; Pl. II, fig. 14 and textfig. 18).

Kophobelemnon Burgeri Herklots. Polypiers nageurs. 1858, p. 24.
Kophobelemnon Burgeri Kölliker. Die Pennatuliden. 1872, p. 307.
Sclerobelemnon Burgeri Balss. Pennatuliden Münchener Museum. 1909, p. 425 and Japanische Pennatuliden. 1910, p. 27.
? *Veretillum clavatum* Stimpson. Proc. Acad. nat. Sci. 1855, p. 375.
? *Kophobelemnon Burgeri* Kölliker. "Challenger" Pennatulida. 1880. p. 16.
? *Sclerobelemnon Köllikeri* Thomson and Henderson. Indian Alcyonaria. 1906 (2), p. 89.
? *Kophobelemnon Burgeri*, var. *indica* Thomson and Henderson. Indian Alcyonaria. 1906 (2), p. 88.

Stat. 49a. 8° 23′ S., 119° 4′ E. Sapeh Strait. 69 metres. 1 Ex.
Stat. 51. Molo Strait. 69—91 metres. 58 Ex.
Stat. 51X. „ „ „ „ 4 Ex.
Stat. 51Y. „ „ „ „ 1 Ex.
Stat. 193. Off Sula Besi. 22 metres. 1 Ex.
Stat. 258. Kei Islands. 22 metres. 1 Ex.
Stat. 294. 10° 12′ S., 124° 7′ E. Off Timor. 73 metres. 1 Ex.

BALSS (1910, p. 27) has already called attention to the extraordinary variability of this species. He had the opportunity of examining eight specimens from Japanese waters and has rendered good service to science by his excellent figures and description of them. With a great many more specimens at my disposal I am able to emphasise BALSS's conclusion. There are specimens in the collection from five different stations varying in depth from 22—91 metres, and there are no less than 59 specimens from one of these stations (51); and, whether the variation of the specimens from different stations or the variations of those from the single station be studied, the species is found to be extraordinarily variable. The variations are obviously not due to general local conditions or the specimens from the single station would be more alike nor are they due to age or size as their detailed description shows. We have

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in this species simply a case in which a wide range of variability is a character of the species.

Of the specimens from Stat. 51, five were preserved in Formol with the autozooids beautifully expanded and deserve special description, the others are preserved in the usual way and are more contracted and broken.

The following table gives some measurements of eleven of the specimens (Stat. 51) preserved in spirit.

	1	2	3	4	5	6	7	8	9	10	11
Total length in mm. . .	40	67	68	76	78	80	80	95	103	109	118
Length of rachis in mm. .	18	38	40	36	42	45	45	63	47	59	69
Length of stalk „ „ .	22	29	28	40	36	35	35	32	56	50	49
Diam. of rachis „ „ .	3	8	5	5	5	7	6	5	7	3	4

As the autozooids in these specimens are nearly all retracted, the figures of the diameter of the rachis do not include the body length of the anthocodiae.

In all cases the shape of the colony may be conveniently called club-shaped although there is considerable variation in the thickness of the club. Both rachis and stalk, unless obviously distorted in preservation are almost circular in section. There is never any distinct groove either on the dorsal or ventral track. The stalk ends in a blunt conical point and in none of the specimens is there a basal swelling (Endblase) a feature which is regarded by KÖLLIKER as a generic character.

The autozooids are arranged on the ventral and lateral sides of the rachis and in all specimens but one there is a track on the dorsal side free from autozooids. In the one exceptional case there were three autozooids in the middle of the dorsal track.

The arrangement of the autozooids is very variable. There is usually a single longitudinal row of large autozooids on each side of the dorsal track extending from the distal end to the upper end of the stalk. The lateral and ventral autozooids are usually quite irregularly scattered although, in some, more or less distinct rows or lines can be distinguished.

As an example, taken at random, the specimen 3 shows six autozooids on each side arranged alternately right and left in the dorso-lateral rows, on the ventro-lateral side of each of these rows there is a second very irregular row of six autozooids and there are three other autozooids on the ventral side that are not arranged in a row at all. Thère are therefore 29 autozooids in this rachis 40 mm. in length.

In specimen 1, one of the smallest in the collection, there are three autozooids in a row on the dorso-lateral sides, two mid ventral, one terminal and three others placed irregularly on the ventro-lateral lines.

In the larger specimens the number of visible autozooids increases but the arrangement in definite longitudinal lines does not become more distinct. A point of some importance as a specific character is that in none of the specimens does the number of autozooids in any transverse section exceed eight. BALSS says of his specimens from Japan "Die Polypen stehen nur undeutlich in 3—4 Längsreihen auf jeder Seite geordnet". For these Siboga specimens a more precise statement would be "The autozooids are arranged in 2—3 very irregular lines on each side of the rachis".

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The autozooids in these specimens show a great variety of stages of contraction but in most of the specimens there is a fold of the sarcosoma at the base of the anthocodiae to form a lip-like verruca (Pl. I, fig. 3).

The autozooids vary so much in size in every rachis that it is difficult to give in a few words an idea of their dimensions. In a specimen 80 mm. in length the largest autozooids of the dorso-lateral rows are about 2 mm. in diameter and the smallest ones 0.5 mm. in diameter. The tentacles also show great variation in length and shape according to their condition of contraction. The longest tentacles measured were 3 mm. in length.

The siphonozooids are also very variable in their arrangement. They are usually scattered quite irregularly on all sides of the rachis. In a few specimens a narrow band on the mid-dorsal track is free from siphonozooids. In some specimens the siphonozooids are arranged in quite definite longitudinal lines, in some they are marked out clearly by a chocolate-coloured pigment, in others they are quite transparent. In one respect only do they show a common character and that is that they never project above the surface of the rachis nor show any special arrangement of supporting spicules.

After careful examination of all the specimens I can say that in none of them is there anything that could be called a rudimentary verruca.

The spicules of the specimens from this station present us with the most bewildering case of variability that I have met with in the group of the Pennatulacea.

In the specimens I have examined the spicules are usually confined to the cortical layers of the rachis, and whatever their shape may be they are very thin flattened plates arranged parallel with the surfaces. Balss states that in some of his specimens there were spicules in the tentacles. I have examined a large number of anthocodiae from several specimens and I can only record the fact that I have not found spicules in any tentacle nor in any of the upper parts of the anthocodiae.

As regards the stalk; my impression is that the spicules do not usually occur in its cortical layers at all; but when they do occur they are of the same type and of the same size as those in the rachis. The difficulty of determining this point is that the stalk of all specimens is encrusted with grains of sand, sponge spicules and pennatulid spicules and it is impossible to be certain whether the spicules seen in the preparations are adventitious or not. When a part of the stalk is carefully brushed there are rarely any spicules at all to be seen but it may be that with the brushing the superficial layers of the stalk are removed.

Passing now to the spicules of the rachis of the specimens from Station 51. They may be roughly divided into two kinds the twins and the quadruplets. In the former a transverse line divides the spicules into two approximately equal parts, in the latter two lines crossing at right angles divide the spicule into four approximately equal parts. The twins may be elongated or dumb-bell shaped the quadruplets may be bun-shaped (like an English hot-cross bun) or rarely cruciform. There is a great variety of forms intermediate between these four types, and some quite irregular.

In the specimen 4 from Station 51, twins and quadruplets are about equally numerous (text fig. 18A) the quadruplets are about .2 mm. × .18 mm. in size, the twins usually smaller

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.18 mm. × .15 mm., .18 × .06. All these spicules have rounded, smooth or undulating margins. The spicules of the distal end of the rachis are the same as those at the base.

In another large specimen from the same station (text fig. 18 E) the spicules are characterised by having thorny, jagged edges, there are very few quadruplets and the twins are chiefly broad double clubs. The size of the larger of these spicules is about .1 mm. × .075 mm. In another smaller specimen (text fig. 18 D) the spicules are of the same type but still more thorny. They are also decidedly larger (0.125 mm. in length).

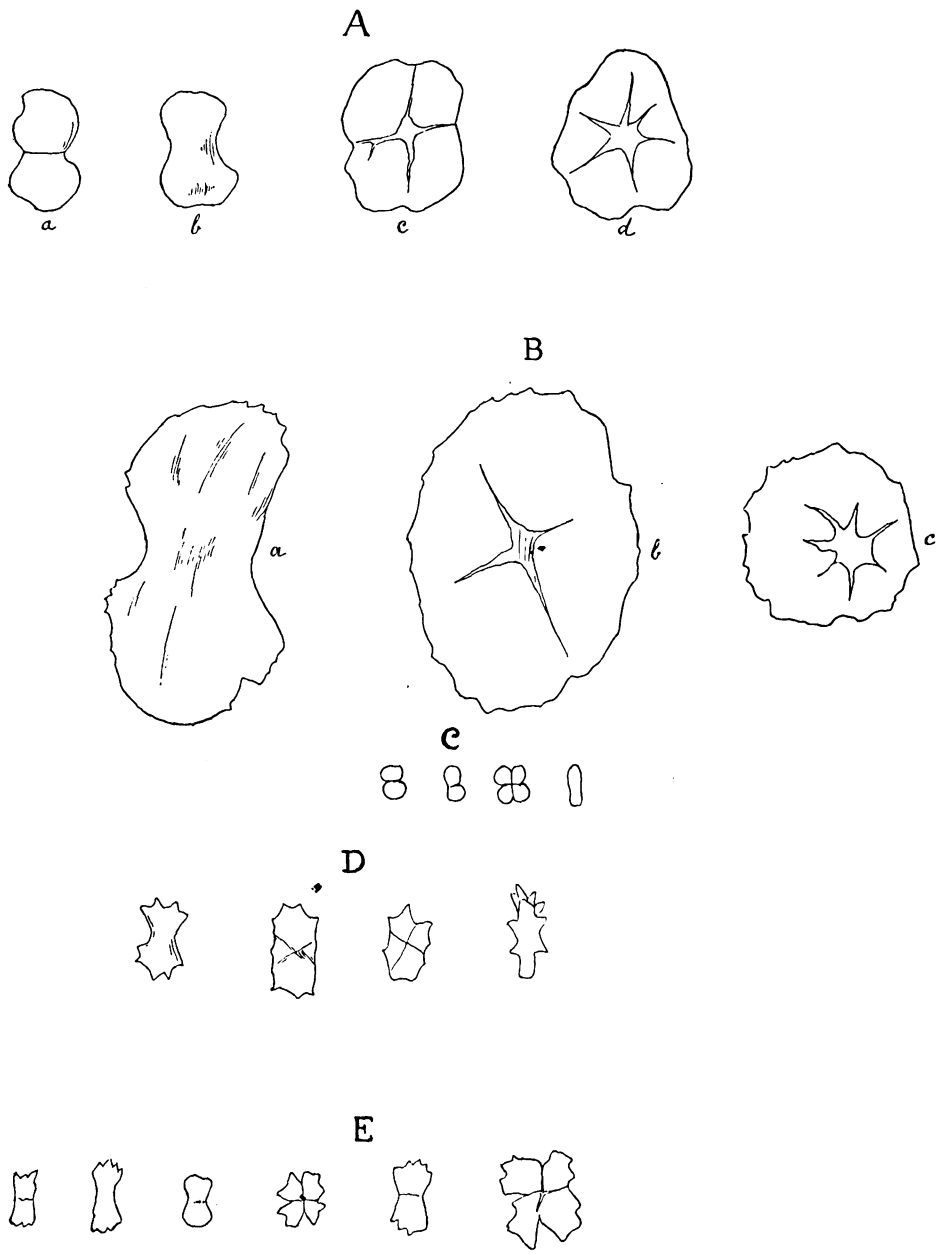

Fig. 18. Spicules of the rachis of *Sclerobelemnon Burgeri*.
A. represents spicules of the average type and size.
a and *b* twins. *c* quadruplet. *d* an irregular form.
B. spicules from another specimen (X) very much larger than the type.
C. spicules from specimen (Y) very small.
D. spicules from another specimen in which edges are more irregular and thorny.
All the specimens from which these spicules were drawn came from Station 51.
E. spicules from a specimen taken at Station 193.
All these drawings were made on the same day by the projection apparatus of Zeiss and are magnified 100 diam.

Two specimens to be described later (Stat. 51 x and y) show a most remarkable difference in the size of the spicules. The most predominant form in both these specimens is the twin dumbbell but there are some quadruplets. In x, (text fig. 18 B) the spicules are .4 mm. in length, in y (text fig. 18 C) they are .04 mm. in length. In both these specimens the spicules have smooth edges.

The spicules of the specimens from this locality collected at the same time vary in maximum length from 0.04 mm. to 0.4 mm. and show a very great variety of general form and of the degree in which their edges are drawn out into thorn like processes. These varieties cannot be correlated with age and size.

The axis of all the specimens is cylindrical but in some a shallow groove extends for some distance along the middle region of one side. The surface is rough and deeply

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scarred by irregular longitudinal ridges. The diameter of the axis of the larger specimens is 1 mm. in the middle ending bluntly above and coming to a fine point below.

The four specimens catalogued above as 51 x were splendidly preserved in 4% formol. The autozooids are more or less expanded and the rachis is distended. There can be no doubt whatever that these specimens represent much more closely than any of the others the natural appearance of the colony and it is therefore important to give a special description of them.

The principal measurements of three of these specimens are given, the fourth specimen was imperfect.

	N° 12	N° 13	N° 14
Total length	75 mm.	50 mm.	32 mm.
Length of rachis. . . .	40 „	26 „	12 „
Length of stalk	35 „	24 „	20 „
Diameter of rachis . .	6 „	6 „	7 „
Diameter of stalk . . .	2 „	2 „	1.5 „

It will be observed that the diameter of the rachis is greater in proportion to its length in these specimens than it is in the others.

The ratio of rachis length to stalk length shows great variation, as it does in all the other specimens, for whereas in the two larger specimens the stalk is shorter than the rachis, in the smallest specimen it is much longer. The transparency of the tissues in these specimens, allowing the siphonozooids to be seen quite clearly by transmitted light, makes these measurements quite reliable and shows that this ratio is of no serious importance as a specific character.

The autozooids are arranged on the rachis in the same general way as previously described and the natural distension of the rachis does not tend to the better definition of the longitudinal rows. The anthocodiae have, when fully expanded, a body length of 2 mm. and the tentacles of some of these are 1.5 mm. in length. The tentacles however show great variation in length, on one autozooid, for example, the tentacles are 4 mm. in length, very slender and filamentous.

The siphonozooids of N° 12 are irregularly scattered on the rachis but there is a very definite dorsal track 1 mm. wide that is free from them, in the other specimens this free track is not so pronounced and in N° 13 may be said to be non-existent.

The spicules of N° 12 are very large and widely scattered on the rachis. Having a measurement 4 mm. in length, their distribution can be seen with a simple lens. In the other two specimens the spicules can be seen by the lens to be much smaller and in N° 13 more numerous and in N° 14 more scattered and scarce.

The single specimen catalogued as Stat. 51^{y} is imperfect, only the rachis being present. It was also preserved in formalin and the autozooids are all fully expanded. The specimen is 27 mm. in length and probably represents very nearly the whole of the rachis. Its greatest diameter is 12 mm. Judging from these figures it seems certain that the specimen was over 50 mm. in total length and very probably over 70 mm. It was not therefore by any means a small specimen and yet the spicules are not more than .04 mm. in greatest length or $^{1}/_{10}$ the length of the largest spicules recorded for the species. The autozooids are arranged in two

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well defined rows on each side of the rachis. The largest autozooids have anthocodiae 3.5 mm. in length by 1.25 mm. in diameter and tentacles 4 mm. in length. These measurements may be regarded as the most accurate measurements of a fully expanded anthocodia that have yet been obtained as it is difficult to believe that the specimen could have been much better preserved.

In a preparation of a whole anthocodia cleared in oil a very long stomodaeum extending the whole length from the mouth to the level of the rachis can be seen. At the base a few spicules are seen scattered about in the cortex. They are of the same types and sizes as those in the rachis. They become fewer in number above the base and at a distance of one third of the total length they totally disappear. The long filamentous tentacles with long widely separated pinnules are perfectly transparent and a very careful search in them shows no spicules at all.

The specimen from Stat. 49[a] is only 33 mm. in length. The rachis is 18 mm. long by 3 mm. in breadth. There is a single row of autozooids on each side of the rachis and two young ones situated mid-ventrally. As the specimen was preserved in corrosive sublimate and acetic acid the spicules have probably been to some extent dissolved, nevertheless there remain a great many quadruplets and some twins reaching a maximum size of 0.1 mm. in greatest diameter or length.

The specimen from Stat. 193 is 43 mm. in length with a rachis 17 mm. long and 4 mm. broad. The special point of interest is that in addition to the usual types of twins and quadruplets there are some rod-shaped spicules with ends divided into a number of spiny processes like a double headed torch a form of spicule that approaches the characteristic type of *Sclerobelemnon (Mesobelemnon) gracile*. The spicules in my preparation of this specimen are even more variable in size than usual but there are some reaching a length of 0.2 mm. In the cortex of this specimen there are some patches of reddish brown pigment which gives it a darker colour.

The specimen from Stat. 258 (Pl. II, fig. 14) is also a small form 18 mm. in length. The autozooids are arranged in lateral rows of seven on each side. The tentacles and calices have a reddish brown colour. The spicules have a great variety of form but are very small, the largest I have measured being only .056 mm. × .029 mm. Many of the spicules are very small and spindle-shaped .013 mm. × .008 mm. The single specimen from Stat. 294 is also a very small one being only 18 mm. in diameter. The point of interest about it is that it was obtained in the same haul of the dredge as specimens of *Sclerobelemnon Gravieri* but it shows some of the characteristic external features of the young specimens of *Sc. Burgeri* and the spicules are flattened plates with a maximum size of about 0.2 mm. × .08 mm. In this specimen the plates almost meet to form a continuous thin cortical sheath of spicule substance and the individual plates are very irregularly distributed. Only a small fragment of the cortex was critically examined and in this most of the plates seemed to be of the twin type. In a similar very small fragment taken from the middle region of the stalk an armature of thin plates was also seen. This is the only specimen of the species in which many spicules have been found in the stalk.

There may be some doubt whether it is a young specimen of *Scl. Burgeri*, as it shows

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some special peculiarities and differs from the other young specimens of the species in the collection. But if it is different from *Sc. Burgeri* it is more widely separated still from the young forms of *Sc. Gravieri* from the same locality.

These very small specimens of *Sclerobelemnon Burgeri* are of great interest for two reasons. In the first place they show that even in the young stages the spicules are very variable both in size, shape and distribution. They do not show a common type from which the many varieties of spicules of the larger forms are derived nor do they afford any reliable evidence that the spicules increase in size very materially after the colony has reached a length of 18 mm. In the second place we find in these smaller forms that the lateral rows of autozooids are the first to be formed and that when the colony is still very small a considerable number (14 or more) are already functional. In the young specimen of *Kophobelemnon pauciflorum* described above and in the young specimen of a *Kophobelemnon* (*sp.*?) figured by KÖLLIKER (1880 fig. 44) only one autozooid appears to be functional. This very great difference between the young stages appears to me to emphasise the distinction of the two genera.

The summary of specific characters may read as follows: —

Colonies of medium size (max. length 120 mm.) with a club-shaped rachis. Autozooids completely retractile arranged in 2—4 very irregular longitudinal lines on each side of the rachis. Siphonozooids very variable in arrangement but usually quite irregularly scattered on all sides of the rachis. Spicules very variable in size and shape but usually very thin plates, twins and quadruplets predominating. Spicules very scarce or absent from the cortex of the stalk. Axis quadrilateral or cylindrical. Widely distributed in the Malay Archipelago in shallow water (22—91 metres) and in rather deeper water in the Philippine and Japanese seas and Indian Ocean.

2. *Sclerobelemnon Gravieri* n. sp. (Pl. I, fig. 5 and text figs 19 & 20).

Stat. 51. Madura bay. 69—91 metres. 6 Ex.
Stat. 294. 10° 12′ S., 124° 27′ E. Off Timor. 73 metres. 9 Ex.

There are six specimens of this new species from the Station (51) that yielded so many specimens of *Sclerobelemnon Burgeri*, and although they have a general resemblance to that species it is not difficult to separate them with a hand lens. The first character that attracts attention is the fact that the siphonozooids are clearly indicated on the surface of the rachis by shallow triangular lips pointing distally. In specimens of *Sc. Burgeri* of the same size the siphonozooids are not nearly so distinct.

The second character is that each of these siphonozooid lips — or rudimentary verrucae as they may be called — is supported by a special group of spicules arranged fan-wise, and the third character is that the spicules of the rachis are all rod shaped in outline although thin and flat as in other species of *Sclerobelemnon*.

The specimens from Stat. 51 were preserved in formol and are beautifully expanded and transparent so that all the characters can be recognised with a strong hand lens.

The nine specimens from Stat. 294 were not preserved in formol and they are obviously more contracted. They are also much more opaque and pale yellow in colour, but the rudimentary calices of the siphonozooids are even more plainly seen than in the formol specimens.

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The following are some of the principal measurements: —

	1	2	3	4	5	6	7	8
Total length in mm.	42	36	24	22	38	34	27	26
Length of rachis in mm. . .	26	25	14	12	21	17	14	13
Length of stalk „ „ . .	12	11	10	10	17	17	13	13
Diam. of rachis „ „ . .	2.5* [1])	2.5*	1.75*	1.5*	2.25*	2.25*	2*	2*
Diam. of stalk bulb in mm. .	1.75	—	—	—	1	—	—	—

The first four specimens are from Stat. 51, the others (5, 6, 7 & 8) from Stat. 294. The other specimens from both stations were more or less imperfect and were not measured.

The rachis is almost cylindrical and shows only a very slight increase in diameter above as compared with that below. It passes gradually into the stalk which is also cylindrical and terminates below in a slight but quite well defined oval basal bulb. There is a pronounced groove running along the mid-dorsal line of the rachis.

In most of the specimens there is only a single lateral row of autozooids on each side but in specimens 1, 2, 5 & 6 and some of the broken specimens from Stat. 294 there is also a complete or incomplete second row, ventro-lateral in position, on each side.

The autozooids of the lateral rows are almost invariably set alternately right and left so that no two autozooids are opposite one another. In specimen 1, there are 10 autozooids in each lateral row of which the proximal 3 or 4 are very small. In specimen 3 there are only 6 in each row. At the base of each anthocodia there is a small but distinct verruca continued some distance down the rachis as a shallow ridge, and, in preparations, the edge of the verruca is seen to be supported by groups of spicules clustered together to form three or four dentate processes.

The fully expanded anthocodiae are in some cases 4 mm. in length, and the stomodaeum can be seen through the transparent walls to be very long as it is in *Sc. Burgeri*. The tentacles appear to be contracted and never exceed 1 mm. in length but it is not safe to regard this point as a distinctive character of the species as compared with *Sc. Burgeri*. There are no spicules in any part of the anthocodiae.

The siphonozooids are not so numerous in proportion to the size of the colony as in the former species and appear to be arranged in more regular longitudinal lines. They are distributed on all sides of the rachis with the exception of a broad track on the mid-dorsal side which is always free from them. The rudimentary verruca with which each siphonozooid is provided gives them the appearance of being larger than the siphonozooids of *Sc. Burgeri* but the stomodea of the two species are of about the same size.

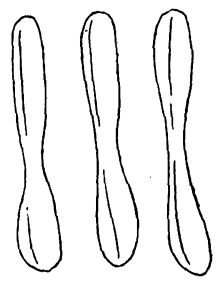

Fig. 19.
Spicules of the rachis of *Sc. Gravieri*. × 100 diam.

The spicules are distributed in considerable numbers in the cortex of the rachis and of the stalk. They are all very thin plates with a rod or bone-shaped outline.

In the calyx of the autozooids they are about 0.18 mm. in length and 0.02 mm. in

1) * These measurements do not include the anthocodiae.

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breadth, nearly straight rods with rounded ends, and some of these spicules exhibit irregular shallow ridges on the surface. Other spicules, attaining to a length of 0.34 mm. and usually more deep seated, are quite smooth. These spicules frequently show a contraction in the middle which gives them a rough resemblance to a humerus bone. There are numerous spicules in the stalk. Most of them are quite smooth flat rods shorter and broader than the spicules of the rachis. Their size varies from about 0.12 × .02 to .08 × .02 mm. Among the crowd of these smooth rods there may be seen a few crosses 0.06—0.08 mm. in length and some more irregularly branched. But all the spicules are very thin and transparent.

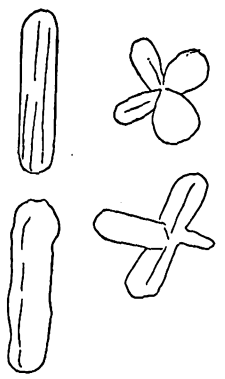

Fig. 20.
Spicules of the stalk of *Sc. Gravieri*. × 240 diam.

Bearing in mind the great variability of *Sc. Burgeri* as regards the spicules several specimens of this new species have been examined, with the result that a much more constant set of measurements has been obtained. There is however some variability in the number of spicules both of the rachis and of the stalk. In some specimens the spicules are much more numerous than in others and the spicules of the stalk are in some cases very scarce.

The axis is usually cylindrical in shape but in one specimen from Stat. 51 it shows four shallow ridges thus becoming almost quadrangular. The surface is marked by finer longitudinal lines than in *Sc. Burgeri*, and comes to a fine flexible point at each extremity.

One specimen from Stat. 51 is a male but the gonads are not ripe. Other specimens from both localities show gonads below the surface of the rachis but the sex was not determined.

The new species which I propose to name *Sc. Gravieri* has a certain general appearance like that of *Sclerobelemnon Burgeri* particularly when it is killed expanded in formol, the four rows of autozooids having about the same size and appearance as the more irregularly distributed autozooids of a specimen of the other species of a similar total length; but it differs from *Sc. Burgeri* in the shape of the spicules, the presence of spicules in the stalk and the presence of distinct verrucae both for the autozooids and for the siphonozooids.

In the character of the spicules the species approaches *Sclerobelemnon (Mesobelemnon) gracile* of GRAVIER (1908 p. 229) from Tadjourah. Concerning the spicules of the stalk of this species GRAVIER remarks "La forme fondamentale de ces spicules pédonculaires est une sorte de bâtonnet à double tête arrondie à chaque extrémité, ayant l'apparence d'un astragale de Mouton un peu allongé". But for their bifurcated heads these spicules remind one of the bone-shaped spicules of the stalk of the new species and they have approximately the same size. In addition to these spicules there are others in *Sc. gracile* which remind one of the twins and quadruplets of *Sc. Burgeri.* Such spicules may occur in the new species but must be very scarce.

Another point of resemblance between these two species is that the rachis spicules are specially aggregated round the base of the siphonozooids and autozooids ("particulièrement autour des siphonozooides et dans la région basilaire des polypes"). GRAVIER does not regard these clusters as rudimentary calices and it is probable that they are not so well developed in *Sc. gracile* as in *Sc. Gravieri*, but this feature shows an affinity between the two species.

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In the arrangement of the autozooids on the rachis *Sc. gracile* is more closely related to *Sc. Burgeri.*

GRAVIER notes the relatively small number of siphonozooids in his specimen. In this respect I have found considerable variations in all the species examined but speaking in general terms *Sc. Gravieri* seems to be intermediate in this character between *Sc. Burgeri* and the single specimen of *Sc. gracile.*

The new species has also some affinities with *Kophobelemnon (Sclerobelemnon) intermedium* of THOMSON and SIMPSON (1909 p. 277) from 97 metres in the Indian Ocean. The spicules of this species are flat rods with or without bifurcated ends (as in *Sc. gracile*) and they form "pseudocalices" round the base of the autozooids. The species however differs markedly from *Sc. Gravieri* in the quadrangular axis, concave on all four surfaces.

A summary of the characters of the species may read as follows: —

Colonies of small size with a cylindrical rachis and stalk, the rachis showing a dorsal groove and the stalk a slight basal swelling. Autozooids arranged in two (lateral) or four distinct longitudinal rows. Siphonozooids arranged in longitudinal rows on the lateral sides of the rachis, elsewhere more irregular, not very numerous and absent along the mid-dorsal track. Both autozooids and siphonozooids provided with verrucae.

Spicules principally flattened rods with rounded extremities some of them provided with shallow ridges. Axis cylindrical. Malay archipelago 69—91 metres.

3. *Sclerobelemnon elongatum*. n. sp. (Pl. II, fig. 12 & Text figs 21 & 22).

Stat. 181. Amboyna anchorage. 54 metres. 20 Ex.
Stat. 320. 6° 5′ S. 114° 7′ E. Java sea. 82 metres. 1 Ex.

A number of slender cylindrical specimens were enclosed in two tubes from the Amboyna anchorage but unfortunately most of them are broken so that only three could be measured as complete specimens. The others represent a part or the whole of the rachis or broken off stalks.

The general superficial appearance of some of these specimens reminds one of *Funiculina*, the long slender autozooids standing out at intervals at right angles to the elongated rachis as in that genus; but in others the autozooids are completely retracted leaving only a lip-like verruca to mark their position.

Observations with a hand lens show at once that the species must be very variable as regards the arrangement of the autozooids and the colour. Microscopic investigation shows that there is also remarkable variation as regards the shape and distribution of the spicules.

There is a great temptation here to make three or four new species but bearing in mind the known variability of the genus as already shown by the writings of BALSS (1910) and the fact that all the specimens, except one, came from the same dredging, there can be little doubt that they are all representatives of one variable species.

The specimens agree with one another in their elongated slender shape, in having flat plate-like spicules in the rachis, in the absence of spicules in the anthocodiae of the autozooids and in the absence of verrucae.

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The three complete specimens have the following measurements:

Total length	50 mm.	120 mm.	150 mm.	50 mm. [1])
Length of rachis	25 „	84 „	110 „	27 „
Diameter of rachis	1 „	2 „	3 „	1 „

None of these specimens are full grown. The oldest specimen in the collection is probably the one represented by a rachis, or part of a rachis 158 mm. in length.

The colony is almost completely cylindrical having the same diameter throughout, and as this diameter is usually less than $^1/_{50}{}^{th}$ of the total length the colonies are all long slender sticks.

On the dorsal track there is usually a shallow longitudinal groove, but this is not shown in all the specimens. The autozooids are arranged in two or four indistinct longitudinal rows. In the oldest specimen the autozooids of a row are situated at regular intervals of 7 or 8 mm. apart in the middle region of the rachis but tend to come closer together at the distal end. At the proximal end the autozooids are for some distance not fully developed and also closer together.

In some of the specimens the autozooids arise from a long diamond-shaped area on the rachis which may be raised to form a ridge (Plate II, fig. 12). In the best preserved specimens this area is quite flat and it seems probable that the ridge is formed in preservation. The diamond-shaped area is a very pronounced feature in the specimens with coloured siphonozooids. There is no trace in any specimen of a rudimentary verruca either for the autozooids or siphonozooids.

The diamond-shaped area bears spicules but, if anything, they are less crowded together there than in other parts of the rachis and do not show any special fan-shaped arrangement.

The autozooids of some specimens are all fully expanded and the anthocodiae may have a length of 4 mm., a diameter of 1 mm. and tentacles 4 mm. long. There is, of course, considerable variation in the length of the anthocodiae, 4 mm. represents an average length of a fully expanded one, the diameter however is much more constant. The tentacles in all these specimens are long and filamentous, the pinnules being long and separated by long intervals usually alternating on opposite sides of the tentacle. In the specimens I have examined I could find no spicules in any part of the anthocodiae even at the base. The stomodaeum is very long extending almost to the base of the anthocodiae.

The siphonozooids in some specimens are marked by chocolate coloured patches so that their position can be seen with the naked eye, in others however they are quite white and can be seen only with difficulty when examined with a hand lens. There is a great variability in their arrangement but it may be said that there is a pronounced tendency for the siphonozooids to be arranged in longitudinal rows. They may be distributed all over the rachis except on the diamond shaped areas from which the anthocodiae of the autozooids arise. In most of the specimens there is a broad track on the dorsal side of the rachis free from siphonozooids and in some of them, particularly the younger forms another track free from them on the ventral side, but in two specimens there is no free track on either side. The relative number

1) From Station 320.

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of siphonozooids varies enormously. In some of the larger specimens they are widely separated and occur in patches or lines, in others they are crowded together on all sides of the rachis.

The spicules of this species are extremely variable in distribution and in shape. Six specimens were carefully examined for spicules and no two of them were alike. In some the elongated rod and dumb-bell forms predominate, in others the plate like forms with jagged edges. In some specimens the spicules are very numerous, in others scarce and isolated.

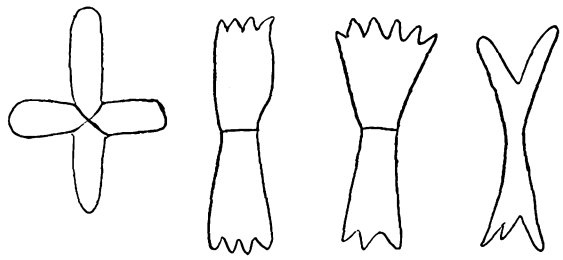

Fig. 21.
Some examples of the very variable spicules of the rachis of *Sc. elongatum.* × 200 diam.

The largest spicules observed were in the specimen mentioned above (p. 91) 158 mm. in length of which only the rachis is preserved. In this specimen rod-shaped spicules predominate and may attain a length of 0.17 mm. with a breadth of about 0.03 mm. In another specimen the rachis spicules vary in shape from rods to dumb-bells and do not exceed .05 mm. in length. In the specimen from Stat. 320 a few spicules were found with double-head extremities (fig. 21) like the spicules described as typical for the species *Sclerobelemnon (Mesobelemnon) gracile* of GRAVIER.

In all the specimens examined a few spicules of the twin and quadruplet types can be found but they vary in number, being much more numerous in some than in others.

Spicules occur in both rachis and stalk but I have not seen any spicules at all in the body wall and tentacles of the autozooids in any specimens examined. The spicules of the stalk (fig. 22) are very variable in shape varying in length from 0.03—0.05 mm.

Fig. 22.
Spicules of the stalk of *Sc. elongatum.* × 200 diam.

The only general summary of the spicules of this species that can be made is as follows: —

Spicules thin plates very variable in outline and distribution varying in maximum length for the individual from 0.17 mm. to 0.05 mm., present in the cortex of the rachis and of the stalk.

The axis is also variable being in some cases quadrangular in section, in others almost cylindrical. Its diameter in the middle of a full grown specimen is about 1 mm. The surface is always marked by a series of course longitudinal ridges.

The colour of some specimens is white. In others the chocolate coloured patches marking the positon of the siphonozooids give the rachis a general pale brown colour. The specimen from Stat. 320 is uniformly brown.

The characters of the species may be summarised as follows: —

Colonies slender with a very elongated rachis. Autozooids widely separated from one another and arranged in two or four indistinct longitudinal rows. Siphonozooids numerous showing a tendency to be arranged in longitudinal rows. No verrucae either for the autozooids or for the siphonozooids. Spicules present in the cortex of rachis and of stalk, very variable in size, shape and distribution but on the whole small, not exceeding 0.17 mm. in length. Axis quadrangular to cylindrical with a very rough surface. Malay Archipelago. 54—82 metres.

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4. *Sclerobelemnon magniflorum* n. sp. (Pl. II, fig. 10 & 11 and text figs 23 & 24).

Stat. 137. 0° 23′ N., 127° 29′ E. Off Halmaheira, 472 metres. 2 Ex.

This very interesting form is represented by two specimens, one complete and the other very much damaged. Like *Sclerobelemnon (K.) intermedium* of THOMSON and SIMPSON (1909 p. 277) it is intermediate in some respects between the genera *Kophobelemnon* and *Sclerobelemnon* and affords one of those difficult cases in which the systematist has to determine whether to establish a new genus, suggest the amalgamation of the two older ones or to establish a new aberrant species of one of the older ones. For reasons given on a previous page I have decided to refer this species to the genus *Sclerobelemnon*.

It differs from the other species of this genus in the great size of the autozooids, in the very reduced number of spicules in both the rachis and the stalk and in the character of the axis. It agrees with them in the type of spicules that are present and in the entire absence of spicules in the body wall and tentacles of the autozooids.

It differs from *Sclerobelemnon (K.) intermedium* of THOMSON and SIMPSON in many respects. The Indian species has completely retractile autozooids and an abundance of spicules in the rachis, but on the other hand it has a similar quadrangular axis with concave surfaces.

The only complete specimen of the species is 80 mm. in total length, the rachis is 56 mm. in length and 2.5 mm. in breadth between the autozooids. The stalk has the same diameter as the rachis but ends in a basal bulb 6 mm. in length by 3 mm. in diameter. The damaged specimen is 70 mm. in length and retains three autozooids at the distal end and a part of the flesh of the stalk. The other parts, excepting the axis, are destroyed.

In the complete specimen there is a distinct groove running down the whole length of the dorsal track of the rachis.

The rachis bears in all 21 autozooids which are arranged as follows. In the upper part of the rachis, one sub-terminal on the mid-ventral line, three pairs opposite to one another on the lateral sides, two pairs ventro-lateral in position which almost meet at their bases in the mid-ventral line. In the lower part of the rachis, where the autozooids become much smaller in size, there are 3 lateral pairs and 4 irregularly distributed ventro-lateral autozooids, two on each side of the mid-ventral line.

In this particular specimen then, apart from the sub-terminal autozooid, the autozooids are arranged in four longitudinal rows on the rachis as in *Sclerobelemnon Burgeri* and the larger specimens of *Sc. Gravieri*. The number of autozooids is decidedly greater than it is in a rachis of a *Kophobelemnon pauciflorum* of the same size.

The sub-terminal autozooid is a feature that reminds one of *Kophobelemnon*.

The larger autozooids have a body length of 11—12 mm. and a diameter of 2 mm. This size may be regarded as approximately intermediate between that of a *Kophobelemnon* and that of a *Sclerobelemnon* autozooid. In this complete specimen the tentacles are contracted and only 4 mm. in length, in the three autozooids of the damaged specimen the tentacles are 10 mm. in length. This is a good example of the difficulty of estimating the value of the length of the tentacles as a specific character. A feature which may be of some importance

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is that there is no evidence that the autozooids can be withdrawn below the level of the surface of the rachis. They have all the appearance of being non-retractile but remembering the power that the thick walled auotzooids of some of the Kophobelemnons have to completely contract it would not be safe to assert on the evidence afforded by two specimens that the autozooids are non-retractile.

The siphonozooids are easily seen, crowded between the bases of the autozooids. The epithelium on the dorsal track is a good deal rubbed but there seems to be little doubt that there is a broad track on the dorsal aspect of the rachis free from siphonozooids. The siphonozooids do not seem to be arranged in longitudinal rows and they are not marked by pigment nor supported by verrucae.

The spicules in this species are very small and very scarce. In a cleared preparation of the rachis they can be found with a high power to be widely distributed, sometimes in clusters sometimes as isolated individuals and considerable areas are entirely devoid of them. Most of these spicules are flat rods with rounded ends and without any ridges; but here and there may be found smaller twins and quadruplets similar to those of other species of the genus (Fig. 23). The rods vary from .035—.04 mm. in length and have a uniform breadth of about .008 mm. the twins and quadruplets vary still more in size but are usually shorter than the rods. In the cortex of the stalk the rods are rather more numerous and the other forms scarcer (Fig. 24).

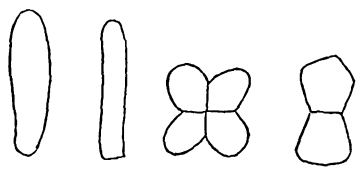

Fig. 23.
Spicules of the rachis of *Sc. magniflorum*. × 500 diam. Note that these spicules are very much smaller than those of the other species.

The axis of the damaged specimen was examined. It is quadrangular in section with deep concave surfaces. Its greatest breadth is about 1 mm.

The specimens are of a pale brown colour.

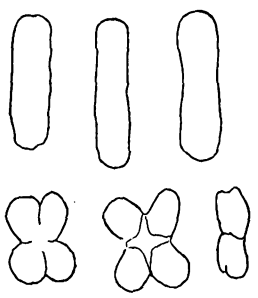

Fig. 24.
Spicules of the stalk of *Sc. magniflorum*. × 550 diam.

As this species is at present represented by only one complete and one imperfect specimen, the following summary of characters are subject to modification.

Colonies of medium size with large, apparently non retractile autozooids arranged in four longitudinal rows. Siphonozooids numerous scattered irregularly on all sides of the rachis except on a broad track along the middle of the dorsal track. Spicules in the rachis very small (max. length .04 mm.) scarce, widely distributed single or in clusters, mostly in the form of flat rods without ridges but several twins and quadruplets. The spicules present in the cortex of the stalk are of the same kind but the rods are more numerous and the other forms scarcer. Axis quadrangular in section with deep concave surfaces. Halmaheira, 472 metres.

Family Funiculinidae.

This family consists of only one genus *Funiculina*, but unfortunately the only specimen collected by the Siboga expedition that may belong to this genus or family is so badly preserved that its position in very uncertain.

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I have had the opportunity, however, of studying several specimens of the genus in the Manchester Museum and also some fragments specially preserved for me by my friend Professor HERDMAN from the coast of Scotland.

These long and slender sea-pens exhibit the very peculiar character that numerous young autozooids are formed during life between the older ones on the rachis, and the young and old autozooids have the appearance of being quite irregularly distributed on the rachis. The autozooids are provided with calices. The spicules are ridged needles and the axis is quadrangular in section.

The siphonozooids were fully described by the MARSHALLS (1882 p. 19) but JUNGERSEN (1904 p. 8) declared that these very small zooids are not siphonozooids but young autozooids. KÜKENTHAL and BROCH (1911 p. 527) re-examined the structure of *Funiculina* and came to the conclusion that JUNGERSEN's view is unsound and that true siphonozooids do occur in the genus; "echte zooide neben den Polypen vorhanden sind". These zooids possess the large siphonoglyph characteristic of siphonozooids but have very small tentacles without pinnules.

Without adding anything to our knowledge of this question I may express the opinion that the absence of siphonozooids in *Funiculina* has not been proved, but at the same time admit the possibility that the siphonozooids may become changed during the growth of the colony and assume the characters of autozooids.

It would, in any case, be unsound to assert that "absence of siphonozooids" is a character of the family or genus.

Genus **Funiculina** ?

Stat. 18. 7° 28′ S., 115° 24′ E. Bali Sea. 1018 metres. 1 Ex.

Reference may be made to a specimen from this station which probably belongs to a species of *Funiculina* but it is so badly preserved that even the generic position must be regarded as doubtful. It was probably dead when taken. It was captured by the dredge at the same time as the well-preserved specimens of *Chunella gracillima* and as it was sent to me in the same bottle as one of these specimens it probably received the same care as the Chunella at the hands of the naturalists of the Siboga Expedition.

On making an examination of the tissues it was found that the whole of the epithelium is lost and the projecting autozooids appear to be composed of a structureless membrane. The total length of the specimen is 219 mm. of which about 60 mm. belongs to the stalk. The diameter of the rachis is 2 mm. and of the stalk 1.1—1.2 mm.

The autozooids are arranged in two very irregular rows one on each side of the lateral surface of the rachis and the largest autozooids are about 2 mm. in length by 0.5 mm. in diameter

The siphonozooids may be represented by a number of small slit like apertures on the rachis between the autozooids.

No spicules were found in any part of the colony that was examined.

The axis is quadrangular.

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The irregular distribution of the autozooids on the rachis and the quadrangular axis are the only characters that suggest that the specimen is a *Funiculina*.

Family Protoptilidae Kölliker.

Protoptileae Kölliker 1872. Die Pennatuliden.
Protoptilidae Kölliker 1880. "Challenger" Pennatulidae.

The family Protoptileae was constituted by Kölliker (1872 p. 380) for three species of the genus *Protoptilum* from the Atlantic Ocean. In 1880 (p. 26) the same author changed the name of the family to Protoptilidae and added as new genera *Microptilum*, *Leptoptilum*, *Trichoptilum* and *Scleroptilum*. He also included in the family the *Lygomorpha* of Koren and Danielssen (1877 p. 99). In 1882 Verrill (p. 362) described the genus *Distichoptilum* which was subsequently included in the family and in 1887 Grieg (p. 15) added the new genus *Stichoptilnm*.

Other genera that have been described and regarded as allied to *Protoptilum* are *Protocaulon* (Köll. 1880 p. 26) placed in a separate family the Protocaulidae, *Deutocaulon* (Marshall and Fowler (1887 (2) p. 461), *Juncoptilum* (Thomson and Henderson 1905 (2)) and finally *Helicoptilum* (Nutting 1912 p. 555).

The systematic position of many of these proposed new genera was discussed by Jungersen (1904 p. 35 etc.) who gave reasons for believing that in several cases they represent the young stages of other well known genera. Jungersen's conclusions have been accepted by Kükenthal and Broch (1911 p. 255) and, in the main, assented to in this memoir.

According to current ideas therefore some of the old genera are disposed of in the following way: —

Lygomorpha = a young Halipteris [1])
Stichoptilum = a young Halipteris
Microptilum = a young Pavonaria
Leptoptilum = a young Funiculina

Trichoptilum = a young Funiculina
Deutocaulon = a young Virgularia
Protocaulon = a young Virgularia
Scleroptilum belongs to a distinct family

Juncoptilum was only mentioned in a preliminary note and is probably an example of *Distichoptilum gracile*.

There remain then in the family Protoptilidae only three genera *Protoptilum*, *Distichoptilum* and *Helicoptilum*.

Of these *Helicoptilum* is very closely related to *Distichoptilum* and should probably be merged with it.

The characteristic features of the family are as follows: —

Very long and slender colonies showing complete bilateral symmetry. Autozooids arranged in 2—4 longitudinal rows, protected by well developed calices. The cortex of the rachis provided with a dense armature of spindle-shaped ridged spicules.

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1) The genus Halipteris has been merged with Pavonaria. *Lygomorpha* and *Stichoptilum* are young stages of *Pavonaria Christii* and *Microptilum* of *P. Willemoesii*.

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The genera may be arranged as follows: —

A. With one or more longitudinal rows of autozooids and many siphonozooids . *Protoptilum*

B. With not more than two longitudinal rows of autozooids and two or three (?) siphonozooids for each autozooid.

1. With spicules in the anthocodiae. . . . . *Distichoptilum*
2. Without spicules in the anthocodiae. . . . . *Helicoptilum*

Genus **Protoptilum** Kölliker.

Protoptilum Kölliker, A. 1872. Die Pennatuliden. p. 370, Pl. XXIII.
Protoptilum Jungersen, H. 1904. "Ingolf" Pennatulida. p. 51, Pl. I.
Protoptilum Balss. 1910. Japanische Pennatuliden. p. 34.
Protoptilum Kükenthal and Broch. 1911. "Valdivia" Pennatulacea. p. 256, Pl. XIV.

There are six established species of this genus and to these I propose now to add a seventh, *P. celebense.*

P. Thomsonii (Köll. 1872) has a wide distribution in the N. Atlantic Ocean, *P. Carpenteri* (Köll. 1872) and *P. denticulatum* (Jungersen 1904) were also found in the N. Atlantic Ocean but seem to have a more restricted distribution. *P. cyaneum* (Kük. 1911) was found off the coast of Somaliland, *P. Wrightii* (Nutting 1908) was found off the Hawaiian islands and *P. orientale* (Nutting 1912) off the coast of Japan. The new species *P. celebense* was found off the coasts of Celebes.

All the specimens were obtained in deep water, the shallowest record being 288 metres for *P. Thomsonii* off the coast of Norway, and the deepest, 3109 metres for a specimen of *P. Carpenteri* N. Atlantic S. of New York.

Protoptilum aberrans (Köll. 1880) from 3109 metres in the North Atlantic and *P. medium* (Thomson and Henderson 1906 (2)) from 250—730 metres in the Indian Ocean, are regarded by JUNGERSEN as examples of *P. Carpenteri. P Smittii* (Köll. 1872) was regarded by JUNGERSEN as a young form but he was uncertain to which species it belongs. If JUNGERSEN is right as regards *P. medium* the species *P. Carpenteri* has rather a remarkable distribution, being found in the North Atlantic and in the Indian Ocean.

It is noteworthy that with the exception of *P. celebense*, which is practically equatorial, no specimens of the genus have been found South of the Equator.

I have not been able to draw up a key plan of the species of this genus, the differences between them being ill defined.

JUNGERSEN's studies of the series of large and small specimens obtained by the Ingolf expedition shows that their young stages are very different in form from the older stages and difficult to distinguish specifically. The following notes however may be of use:

In *P. Thomsonii* the autozooids may be arranged in 2—4 longitudinal rows on each side of the rachis.

In *P. celebense* so far as is known they are arranged in not more than two rows on each side of the rachis.

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In *P. Carpenteri*, there is usually only one row on each side of the rachis but in the larger specimens there may be two rows.

P. celebense differs from *P. Carpenteri* in having a dense armature of spicules in the anthocodiae, in *P. Carpenteri* the spicules are confined to the "stem of the tentacles".

P. Wrightii resembles a young *P. Carpenteri* in having the autozooids arranged in one row on each side of the rachis, but it has no spicules in the tentacles.

P. denticulatum appears to be the young stage of a distinct species of Protoptilum. It has the autozooids arranged in one row on each side of the rachis, but it shows 6 remarkably long calyx teeth on all the autozooids.

P. Smittii is a young stage of some species of Protoptilum. It has the autozooids arranged in one row as in *P. denticulatum* but the calyx teeth are broader and more irregular.

P. orientale, judging from the figure given by NUTTING, is much more robust in form than any other species. There is one row of autozooids on each side of the rachis.

The genus may be defined as:

Protoptilidae in which there are more than 2—3 siphonozooids for each autozooid. The autozooids are arranged in one or more than one row on each side of the rachis.

1. *Protoptilum celebense* n. sp. (Pl. III, fig. 19; Pl. VI, fig. 36 and text fig. 26).

Stat. 87. 0° 32′ S., 119° 39′ E. Palos bay, Celebes. 655 metres. 1 Ex.
Stat. 208. 5° 39′ S., 122° 12′ E. Buton Strait. 1886 metres. 1 Ex.
Stat. 212. 5° 54′ S., 120° 19′ E. Saleyer Island. 462 metres. 1 Ex.

The three specimens of this species are of particular interest because they differ so much in size and yet clearly belong to the same species.

The following measurements were taken:

	Stat. 208.	Stat. 212.	Stat. 87.
Total length	240 mm.	23 mm.	
Length of rachis.	145 „	7 „	A part of the rachis only. 145 mm.
Length of stalk	95 „	14 „	
Width of rachis	2 „	0.9 „	5 „
Length of spicules of the tentacles. .	0.2 „		0.33 „
Length of the rachis	0.8 „		1.04 „

The specimen from Station 87 (Pl. III, fig. 19) is a part of the rachis of what must have been much the largest specimen of the three.

The autozooids are in many places arranged in indistinct whorls of 4, two lateral and two ventral, but the bases of the autozooids of a whorl never arise at exactly the same level. The autozooids are provided with calices supported by numerous spicules which form two well marked points or spines. These calices are closely adpressed to the side of the rachis and the opening is directed upwards.

From the mouths of the calices a part of the body wall and tentacles of the anthocodiae project. The body wall of the anthocodia is provided all round with a dense armature of

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spicules of the same type as the spicules of the tentacles. To what extent it is capable of being retracted into the calyx cannot be determined.

The tentacles are very long (about 7 mm.) and provided with few lateral pinnules. The axial part of the tentacle has numerous spicules but the pinnules are usually unarmed.

The siphonozooids are distributed on the dorsal track of the rachis leaving only a narrow band in the middle free. A few siphonozooids are also found between the autozooids on the lateral and ventral sides of the rachis. Each siphonozooid shows a small verruca with two lateral teeth and is very much like an autozooid calyx on a small scale.

The rachis is provided with a dense armature of spicules. These spicules are long narrow spindles pointed at each end and provided with ridges. The largest of them are about 1 mm. in length by 0.06 mm. in greatest breadth.

The spicules of the tentacles are short rods slightly compressed in the middle and rounded at the ends. They have a fairly uniform length of 0.33 mm. with a width of 0.069 mm. in the centre and 0.087 mm. at the ends. These spicules also show delicate longitudinal ridges.

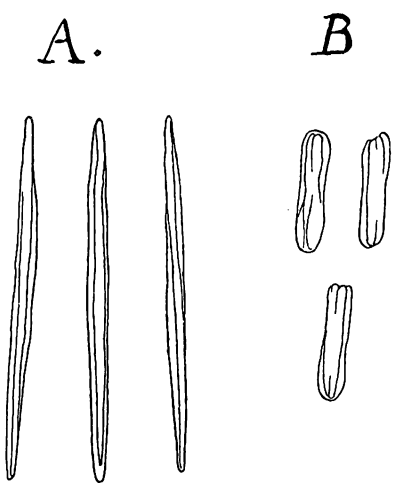

Fig. 25. *Protoptilum celebense.*
A. Spicules of rachis. × 50.
B. Spicules of tentacles. × 50.

The axis is entirely missing.

The colour of this specimen, due to the colour of the spicules, is dark red.

The specimen from Stat. 208 is very long and slender but complete. The autozooids do not appear to be arranged in definite whorls, but there are three indistinct longitudinal rows of autozooids one ventral and two lateral. The calices are of the same type as in the specimen from Stat. 87, and the siphonozooids have apparently the same distribution being indicated by groups of spicules forming rudimentary verrucae.

The anthocodiae project from the calices and their body walls and tentacles are provided with spicules. The tentacles are very long 8—10 mm.

The stalk is long and slender, terminating below in a basal bulb about 8 mm. in length and 2.5 mm. in diameter.

The spicules of the rachis are about 0.88 mm. in length by 0.057 in greatest width, the spicules of the tentacles are 0.2 mm. in length with a width of .052 mm. in the middle and 0.069 mm. at the ends. They are of the same type as in the specimen from Stat. 87 but a little smaller.

There are apparently no spicules in the stalk, a small piece cut out of the stalk and examined with the microscope showing no spicules. It is quite possible that spicules would be found if the whole stalk were examined with the microscope but the pale colour of the whole stalk suggests that the spicules are rare or absent.

The axis can be seen at the base of the rachis. It is cylindrical in shape, 1 mm. in diameter and pale yellow in colour.

The greater part of the stalk is quite flexible and does not contain any axis. It is just possible that the part of the axis in the stalk has been lost through a wound in the upper

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part but it is noteworthy that the little specimen from Station 212 which has no such wound has also a perfectly flexible stalk.

The colour of the rachis is pale red, of the stalk dull yellow.

The small specimen from Stat. 212 (Pl. VI, fig. 36) which is only 23 mm. in total length has a remarkable short rachis. There are four large calices, two terminal and two lateral from which anthocodiae protrude and about 15 smaller calices (the exact number is difficult to count) but it is impossible to determine at this stage without microscopic examination of sections whether they contain autozooids or siphonozooids. The tentacles of the expanded autozooids are 3 mm. in length and are provided with spicules.

The stalk immediately below the rachis is 0.35 mm. in diameter, then it gradually expands to a diameter of 0.5 mm. In this region there is a short bend and for the remainder of its length it is quite flexible. It terminates in a bulb 1.9 mm. in length and 0.6 mm. in diameter attached above to the stalk by a narrow constriction 0.2 mm. in diameter.

The colour of the rachis is red, of the stalk pale yellow.

Protoptilum celebense differs in several characters from all the other species of the genus but is most closely related to *P. Thomsonii*.

It differs from all the other species in having no spicules in the stalk and in having crowded spicules in the body wall of the anthocodiae as well as in the tentacles.

It resembles the type specimen of *P. Thomsonii* in having the autozooids in 4 longitudinal rows 2 lateral and 2 ventral in the widest part of the rachis and in having calices that are feebly developed, but differs from JUNGERSEN's larger specimens of this species in which these are eight rows of autozooids.

It differs from *P. Thomsonii* in having the autozooids much more crowded on the rachis and the siphonozooids proportionately much less numerous, in having not more than two teeth (points) to the calyx, in having a darker red colour and larger spicules.

KÖLLIKER's specimen of *P. Thomsonii* was 145 mm. in length and evidently younger than our specimen of 240 mm., but the spicules of the rachis in his specimen were only 0.36 mm. in length, in ours 0.8 mm. in length. The colour of his specimen was described as follows (1872 p. 373): —

"Die Farbe des Kieles ist weisslichrosa in verschiedenen aber stets sehr hellen Nuancen" and he adds that this colour is entirely due to certain spicules in the calices and tentacles. In our specimen, of *P. celebense* 240 mm. in length, it is uniformly pale red and in the larger one dark red.

In *P. Carpenteri* the colour of the rachis is dark red (intensiv rot) as it is in our larger specimen of *P. celebense*.

On comparing KÖLLIKER's account of the type with JUNGERSEN's account of this species it may be observed that the differences between the two species *P. Carpenteri* and *P. celebense* are to some extent bridged over, some of JUNGERSEN's specimens being "brighter" red, having more crowded autozooids and larger spicules than the type but the body wall of the anthocodiae is described as colourless and therefore presumably devoid of the spicules. It is unfortunate that JUNGERSEN does not state whether there are or are not spicules in the stalk.

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Genus **Distichoptilum** Verrill.

Distichoptilum Verrill. Am. J. Sci. 1882. p. 362.
Distichoptilum Jungersen. "Ingolf" Pennatulida. 1904, p. 62, Pl. I.
? *Funcoptilum* Thomson and Henderson. Ann. N. H. XV, 1905, p. 555.

The genus was established by VERRILL in 1882 for a specimen obtained off Nantucket island in 1280 metres of water. In 1894, STUDER described as a new species specimens obtained in the Pacific Ocean from depths of 1618—2876 metres.

In 1904 JUNGERSEN gave good reasons for believing that the Atlantic and Pacific specimens should be placed in one and the same species. Specimens have since been described from deep water in the Indian Ocean (THOMSON and HENDERSON 1906 (2)), off the coast of California (NUTTING 1909) and off Gibraltar (2055 metres, BROCH 1913 (1)).

The principal distinguishing characters of the genus are; (1) the calices closely pressed against the sides of the rachis, and (2) the regular distribution of the siphonozooids in pairs, one pair in relation to each calyx. These two characters are quite sufficient to distinguish the genus from any other Pennatulid except *Helicoptilum* and from *Helicoptilum* it is distinguished by the presence of spicules in the tentacles.

The genus *Helicoptilum* (Nutting 1912) has also the autozooids arranged alternately in a single row on each side of the rachis and two or three siphonozooids to each autozooid but was described as different from *Distichoptilum* in its stiff spiral habit of growth. According to STUDER, *Distichoptilum Verrillii* is also spiral in growth, and this character, therefore, does not seem to be a sufficient reason for separating the genera. A more fundamental difference, however, is that in *Helicoptilum* there are no spicules in the anthocodiae ("polyps"). In all the specimens of *Distichoptilum* that I have examined there are numerous spicules in the tentacles and for this reason the generic name *Helicoptilum* should be retained.

There is only one species, *H. rigidum* (Nutting 1912) from Bering island and off the coasts of Japan in 995—4860 metres.

The specimens of the genus *Distichoptilum* collected by the "Siboga" expedition are of considerable interest because they exhibit very great variation and prove almost conclusively that the suggestion made by JUNGERSEN that *D. gracile* and *D. Verrillii* are identical, is correct.

In the longer specimen from Stat. 271 we find that, at the distal end, the calices are 2 mm. or more apart as in *D. Verrillii* and in the proximal part of the rachis they are much more crowded together as in the type of *D. gracile*. In this specimen also we find, as in *D. gracile*, that the calices alternate regularly on the lateral sides of the rachis increasing regularly in size from below upwards, but in the smaller specimen from the same locality the calices are directed towards the ventral side of the rachis and do not increase regularly in size from below upwards. Moreover in the latter specimen the calices project much more prominently from the surface of the rachis than in any other specimen I have seen.

The specimens from Station 45 are characterised by the relatively greater distance apart of the calices all along the rachis, and by the fact that the calices are so closely pressed against the sides of the rachis that each one projects only to a small degree like a short lip

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or shelf (Plate I, fig. 6). The number of teeth is very variable even in the calices of the same specimen. The spicules of the rachis vary in length from 0.6 mm. in the specimen from Stat. 271, to 0.3 mm. in the specimens from Station 45.

The colour varies from brownish red to pale yellow and white.

An amended diagnosis of the genus might read as follows: Slender or very slender Protoptilidae, with autozooids arranged alternately in a single row on each side of the rachis, each protected by a calyx closely pressed to the side of the rachis and provided with two or more teeth on its abaxial edge. The axial side of each calyx fused with the rachis. Siphonozooids without verrucae, arranged in pairs one on the dorsal and one on the ventral side of the rachis a short distance above each autozooid. Axis extends the whole length of the colony, quadrangular in shape for the whole or part of its length. Spicules abundant in calices, rachis, stalk, and in the tentacles. The spicules of the rachis are rods expanded in the middle, ridged and rounded at the ends 0.3—0.8 mm. in length. The spicules of the tentacles are rods with rounded ends 0.1 mm.—0.05 mm. in length.

Probably cosmopolitan in deep water.

Two species have been described *D. gracile* Verrill and *D. Verrillii* Studer (1894 p. 59), but as shown by JUNGERSEN these two species cannot be kept apart.

1. *Distichoptilum gracile* Verrill. (Pl. I, figs 6 & 7; textfigs 26 & 27).

D. gracile Verrill. Am. J. Sci. XXIII, 1882, p. 362, Note.
D. gracile Verrill. Bull. Mus. Comp. Zool. XI, 1883, p. 8, Pl. I.
D. Verrillii Studer. Bull. Mus. Comp. Zool. XXV, 1894, p. 59.
D. gracile Jungersen. Ingolf Pennatulida. 1904, p. 62, Pl. I.
D. gracile Thomson and Henderson. "Investigator" Alcyonarians. 1906, Pl. IV, p. 87.
D. Verrillii Nutting. Proc. Nat. Mus. XXXV, 1909, p. 713, Pl LXXXVII.
D. gracile Broch. "Michael Sars" Pennatulacea. 1913, p. 3 textfig.

Stat. 35. 8° 0′ S., 116° 59′ E. Bali Sea. 1310 metres. 1 Ex.
Stat. 45. 7° 24′ S., 118° 15′ E. Off Sumbawa Island. 793 metres. 3 Ex.
Stat. 85. 0° 36′ S., 119° 29′ E. Off W. Celebes. 724 metres. 1 Ex.
Stat. 122. 1° 58′ N., 125° 0′ E. Off N. Celebes. 1264 metres. 1 Ex.
Stat. 271. 5° 46′ S., 134° 0′ E. Off Aru Islands. 1788 metres. 2 Ex.

The two specimens from Stat. 35 are very small and probably quite young. In both the stalk is broken and a small part of it is missing. One of them is 17 mm. and the other 32 mm. in total length.

The specimens from Stat. 45 are larger. One has no stalk and what remains of the rachis is 295 mm. in length, another specimen is 70 mm. in length and a third is in two pieces, one piece consisting of stalk is 110 mm. in length, the other piece consisting of rachis is 90 mm. in length. Both pieces are considerably damaged and it is very doubtful whether they belong to the same colony or not.

The specimens from Stat. 271 possess a stalk continuous with the rachis but the smaller one may have lost a little piece of the distal end of the rachis. One of them is 237 mm. and the other 100 mm. in length.

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The specimen from Stat. 122 is very slender, 312 mm. in length with a maximum diameter in the rachis of 1 mm. The stalk is 90 mm. in length and ends below in an oval swelling.

As the eight specimens in the collection differ from one another in several respects, it is necessary to give a description of the principal varieties.

The larger specimen from Stat. 271 (Plate I, fig. 7) has a rachis 157 mm. and a stalk 80 mm. in length. It is apparently quite perfect. It is a very slender pennatulid with a maximum width in the rachis of 2 mm. and in the stalk of 1.5 mm.

The autozooids are arranged alternately in a single row on each side of the rachis and each autozooid is protected by a curved fan of spicules forming a calyx, projecting upwards from the sides of the rachis at an angle not exceeding 45°.

At the distal end of the rachis the distance between the lip of one calyx and the lip of the next calyx of the same row is about 6 mm., in the middle of the rachis this distance is reduced to 3 mm. and at the proximal end the calices become quite rudimentary and very close together. There is very great variation in the arrangement of the spicules on the calyx. In some cases they are arranged in such a manner as to form two teeth, as in *D. Verrillii* of STUDER, in others they form several teeth as in JUNGERSEN's specimens of *D. gracile.*

The anthocodiae are tightly retracted into the calices but in one or two cases two or three of the tentacles project. Comparing these projected tentacles with those that can be dissected out from the calices it appears that the tentacles are short and provided on each side with numerous short close-set pinnules. Along the outer border of the axis of the tentacle there is a dense row of overlapping spicules. It cannot be determined whether these spicules extend on to the body wall of the anthocodia but judging from the dissections I have made I believe they do not. There is in each anthocodia a large stomodaeum probably of considerable length when expanded but tightly packed concertina-fashion in the specimens.

On the dorsal and on the ventral track of the rachis of this specimen there is a narrow shallow groove.

The siphonozooids are arranged in pairs, each pair being situated on the rachis a short distance above a calyx, one siphonozooid of the pair on its dorsal side and the other on its ventral side. The spicules with which the rachis is richly armed, never form even a rudimentary verruca for the siphonozooids but leave a small oval space free from spicules in the centre of which the siphonozooid is placed. The siphonozooids are not always very easy to see in this species. If the rachis is badly contracted the oval space becomes closed up and then the siphonozooid can only be seen in a cleared preparation. It is possible therefore that other siphonozooids may have been overlooked.

In the description of the type, VERRILL states there are three siphonozooids to each autozooid and THOMSON and HENDERSON say that there may be two or three. It is therefore of some interest to note that having carefully examined the whole length of this beautifully preserved specimen in which the siphonozooids can be observed much more clearly than in any of the others, I have not seen more than two.

The stalk is very slender and cylindrical in shape gradually increasing in diameter from

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the distal to the proximal end but without any distinct swelling either above or below. The cortex is armed throughout with numerous spicules.

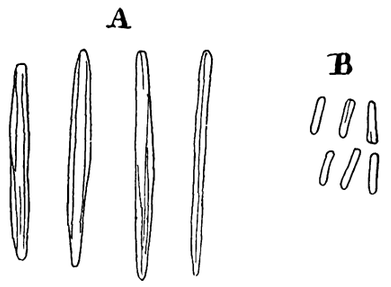

Fig. 26. *Distichoptilum gracile.*
A. Spicules of rachis and calyx. × 50 diam.
B. Spicules of stalk. × 50 diam.

The axis in the only part of its course in which it is exposed — a little below the middle of the rachis — is quadrangular with very rounded edges. It extends right down to the basal end of the stalk.

The spicules of the calices and rachis are rods with very rounded ends, slightly swollen in the middle. They are distinctly ridged. The size is approximately 0.6 × 0.05 mm. The shape of these spicules is very similar to that given by THOMSON and HENDERSON (1906 Pl. IX, fig. 2) but these authors do not show the ridges that are present in this and in all the other specimens in our collection.

Fig. 27.
Distichoptilum gracile.
Spicules of the tentacles in position. × 45 diam.

The spicules of the stalk are short rods 0.11 × 0.02 mm. with rounded ends, parallel sides and distinctly ridged.

The spicules of the tentacles are similar to those of the stalk but larger 0.21 × 0.03 mm. (fig. 27).

The colour throughout is very pale yellow to white.

The smaller specimen from Stat. 271 has a rachis 60 mm. in length (but a part at the distal end may be missing) and a stalk 40 mm. in length.

It differs in several respects from the larger specimens. It is a good deal thicker in proportion to its length the calices stand out almost at right angles to the rachis and they are distinctly turned towards the ventral aspect of the rachis in such a manner that the ventral track is almost obliterated. Moreover the autozooids are not arranged as in the first specimen in regular order of size from above downwards but smaller autozooids are interposed between the larger ones as in *Funiculina*.

At first sight this specimen appeared to belong to a distinct species but a careful detailed examination of the spicules, of the siphonozooids and of the anthocodiae combined with the consideration that the two specimens came up in the same haul of the dredge leaves no doubt that it should not be separated from the others. At the base of each of the anthocodiae there is a distinct swelling due to the presence of a quantity of foraminiferous sand enclosed by the tentacles and there can be little doubt that this swelling has forced the calices outwards, and also, but this is not so certain, towards the ventral aspect of the rachis.

The colour of this specimen is the same as that of the others.

The first specimen from Station 45 is broken off at the base of the rachis and there is no stalk. It is much more slender than either of the specimens from Station 271 having a maximum width of 1 mm. with a length, of rachis only, of 295 mm.

The autozooids are arranged alternately and laterally but the distances between the autozooids on each side of the rachis are greater throughout than in the specimens from Station 271. At the base of the rachis there is a long row of immature autozooids.

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The calices are so closely pressed against the sides of the rachis as to have the appearance of lip-like shelves.

The siphonozooids are two in number for each calyx and arranged in the same manner as in the other specimens.

The axis is quadrangular.

The spicules of the rachis and of the tentacles are of the same shape but smaller than those of the specimens from Stat. 271, the spicules of the rachis being only 0.3 mm. in length.

The colour is pale yellow.

The other specimen from Station 45 is in three pieces: —

1. A stalk 110 mm. in length and 1 mm. in diameter with a distinct basal bulb 5 mm. in length and 2 mm. in diameter.
2. A portion of a rachis 70 mm. in length and 0.5 mm. in diameter.
3. Another portion of a rachis 90 mm. in length and 0.5 mm. in diameter.

In all three fragments the axis is quadrangular and the colour reddish brown. The spicules of the rachis have the same shape and size as the spicules in the other specimen from the same locality.

The interest of these fragments, which may or may not belong to the same colony is that they show the same characters as the other specimen from the same locality, but judging from the condition of the autozooids they may have been dead or dying when captured (Pl. I, fig. 6).

In a separate tube, also from Station 45, there is a small but apparently complete specimen 70 mm. in length, a rachis or part of a rachis 90 mm. in length and a part of a stalk 110 mm. in length.

These specimens are distinguished from the others by their very slender shape, the shortness of the calices and their dark reddish brown colour.

The complete specimen has a rachis 40 mm. in length and a stalk 30 mm. in length, and in no part of the whole colony is it more than 0.5 mm. in diameter. The stalk ends in a slight conical swelling and is sharply curved.

The piece that consists of rachis only is very similar in character to the rachis of the complete specimen. It is very slender has small calices arranged alternately at distances of 2—3 mm. apart on the sides and is not more than 0.5 mm. in diameter.

The part that consists of stalk only is 1 mm. in diameter and has at its base a bulbous swelling 5 mm. in length by 2 mm. in diameter.

All the specimens in the tube are very much damaged, there are no teeth to the calices, most of the calices are empty or filled with mud and the tissues are shrunken or disintegrated. Their appearance suggests that they were dead or moribund when captured.

One of the anthocodiae was sufficiently well preserved however to show that there are spicules of the characteristic shape in the tentacles. The spicules of the rachis are similar to those of the other specimens although rather smaller (0.35 × 0.016 mm.), the axis is quadrangular in the rachis but becomes almost cylindrical in the stalk with a deep groove down one side and where they can be seen there appear to be only two siphonozooids to each calyx.

In these respects they resemble the other specimens of the species, but in the great

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distance apart of the small calices, the absence of definite teeth to the calyx, the reddish brown colour and the very slender form they are very different.

It is difficult to determine whether the differences between the specimens from Station 45 (depth 794 metres) and those from Station 271 (depth 1788 metres) are racial or environmental. It will be observed that there is a great difference in the depth of water from which they were obtained. It might have been anticipated that the forms from deeper water would have their calices further apart and not so well developed; but this is not the case, it is the specimens from the shallower water that have the smaller and more distant calices.

The two very young specimens from Stations 35 and 85 are much more closely related to the specimens from Station 271 than they are to those from Station 45.

The smaller one from Station 85, 17 mm. in length, has three calices on one side of the rachis and two on the other, the largest of these calices is 3 mm. in length. The stalk is damaged.

The other specimen from Station 35, 32 mm. in length, has a rachis of 13 mm. and a stalk of 19 mm. but the end of the stalk is also broken off. There are six prominent calices on each side.

Both specimens are white in colour.

There can be no question that these two small specimens belong to the same species as the larger specimen from Station 271. The only question is whether the specimens from Station 45 and the smaller specimen from Station 271 are distinct. It is only after very careful consideration of the variations that occur in the course of the rachis of the larger specimen from Station 271 and a comparison of these variations with the other specimens that I have come to the conclusion that they are not distinct.

Family Chunellidae Kükenthal.

Chunellidae Kükenthal 1902. Zool. Anz. XXV, p. 302.
Chunellidae + *Scleroptilidae* Jungersen 1904. Pennatulidae. Ingolf Exped., p. 8.
Chunellidae + *Scleroptilidae* Kükenthal and Broch 1911. "Valdivia" Pennatulacea. pp. 265, 270.

The family Chunellidae was established by Kükenthal in 1902 for certain remarkable sea-pens (arranged by him in two genera) that were found by the "Valdivia" expedition in deep water off the E. coast of Africa. He considered that this family was so far distinct that it should be set apart in a separate Section of the Pennatulacea which he named the Verticilladeae. In their magnificent memoir on the Valdivia Pennatulacea, however, Kükenthal and Broch changed the name of the Section to *Pennatulacea verticillata* and included in it the families Scleroptilidae and Umbellulidae. The section according to their system is arranged as follows: —

Family Scleroptilidae . .	Genus *Calibelemnon*
	Genus *Scleroptilum*
Family Chunellidae . . .	Genus *Amphiacme*
	Genus *Chunella*
Family Umbellulidae . . .	Genus *Umbellula*.

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The family Umbellulidae is clearly defined from the other two families by the arrangement of the autozooids in a cluster or a series of closely set whorls at the distal end of the rachis.

The other two families are alike in having the autozooids arranged in whorls along the whole length of the rachis but differ, mainly, in the greater distance separating the whorls in Chunellidae than in the Scleroptilidae.

In three of the genera of these two families (*Calibelemnon*, *Amphiacme* and *Chunella*) there are no spicules in the rachis. In *Scleroptilum* on the other hand spicules occur throughout the colony.

The specimens collected by the Siboga expedition that I have described under the genus *Chunella* appear to me to bridge over the gap between the two families and to render it a matter of considerable difficulty to clearly define the limits of the three genera of Chunellidae.

In the specimens attributed by KÜKENTHAL to the genus *Chunella* the distance between the whorls varied from 30 mm. to 76 mm. and in those attributed to the genus *Amphiacme* from 20 mm. to 40 mm.

In a specimen collected by the "Siboga" which undoubtedly belongs to the species *Chunella gracillima*, the number of whorls is much greater than in any of the Valdivia specimens and the distance between them varies from 45 mm. to 50 mm.

In a tube containing 13 specimens from very much shallower water (216 metres) a Chunellid was found which had all the appearance of an *Amphiacme* on a small scale, the distance between the whorls being only 8 mm., and in a smaller specimen of the same species from a still shallower locality the distance is reduced to 5 mm.

To these specimens I have given the name *Chunella biflora*.

The smallest specimen however (Plate I, fig. 2) cannot be distinguished from the genus *Calibelemnon* of NUTTING by anything more than specific characters.

Turning now to another difference between the families given by KÜKENTHAL and BROCH (1911 p. 154).

In Scleroptilidae the whorls are not clearly defined (undeutlich) whereas in the Chunellidae they are clearly defined (deutlich).

There can be no doubt that in the Valdivia specimens of the Chunellidae and in the Siboga specimens of *Chunella gracillima* the whorls, standing far apart from one another on the rachis are quite clearly defined but in some specimens of *Chunella biflora* the whorls are well defined and in others they are not and in the specimens attributed to the genus *Calibelemnon* by BALSS (1910) some (*C. indica*) have the whorls well defined and in others (*C. Hertwigi*) the autozooids are more irregularly disposed.

There can be little doubt therefore that if the species recorded here as *Chunella biflora* is a true *Chunella* the important differences between the two families Chunellidae and Scleroptilidae are bridged over.

Before discussing the correctness of this identification it is necessary to make some comments on the characters attributed to the three genera.

KÜKENTHAL (1902 p. 303) separated from the genus *Chunella*, four specimens of a Chunellid which show two autozooids in a whorl instead of three or four and placed them in

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a genus *Amphianthus* which was subsequently changed to *Amphiacme* (K. and B. p. 276). The difference between *Chunella* and *Amphiacme* is expressed as follows: "Als wichtigste art- und gattungsscheidende Merkmale kommen vor allem in Betracht die total verschiedene Anordnung der Polypen, sowie der wohlausgebildete Endpolyp".

It appears to me that the resemblances between *Amphiacme* and *Chunella* far outweigh the differences and the constitution of a distinct genus for the specimens called *Amphiacme abyssorum* is an example of a quite unnecessary multiplication of generic names.

If it were necessary to constitute a separate genus for *Amphiacme abyssorum* with two autozooids in each whorl it would be just as necessary to constitute a distinct genus for *Chunella quadriflora* with four autozooids in the whorls.

The number of autozooids in each whorl is probably not so constant as would appear from the study of a few specimens. In the single specimen of *Ch. quadriflora*, the number of autozooids in each whorl varied from 3—4 (K. and B. p. 275) and in the description of the specimens of *Amphiacme abyssorum*, KÜKENTHAL and BROCH describe several cases of a third but smaller autozooid in the whorls.

The presence of a single autozooid at the distal extremity of the rachis (wohlausgebildete Endpolyp) is also not a character that can be relied upon either for generic or specific distinction as is shown by the variation in this part of the rachis of the thirteen specimens of *Chunella biflora*.

The two genera *Chunella* and *Amphiacme* ought therefore, in my opinion, to be amalgamated.

The genus *Calibelemnon* was founded by NUTTING (1908 p. 562) for a number of specimens found in depths of 154—1274 metres off the Hawaiian islands. The definition of the genus given by him is as follows: —

"Spicules almost or completely wanting; sarcosoma thick and fleshy; polyps large, the general arrangement being in pairs".

In the general description he gives the total length of a specimen as 108 mm. but does not mention the number of pairs of autozooids. The length of the autozooids is given as 2—3 mm. and they are said to contain ova at the base. The siphonozooids are found over the entire surface of the rachis except on the dorsal and ventral tracks.

BALSS (1910 p. 70) has carefully reinvestigated the genus. He examined specimens from Japan of the type species *C. indicum* and described a new species *C. Hertwigi*. As a result of his investigations he has been able to add to the characters of the genus the presence of siphonozooids on the stalk.

Upon careful analysis of the characters there is really very little difference to be found between the genera *Chunella* and *Calibelemnon*.

The three characters that would distinguish them are: —

1. the whorls are far apart in *Chunella*, close together in *Calibelemnon*;
2. there are spicules in the stalk of *Chunella* none in the stalk of *Calibelemnon*;
3. there are no siphonozooids in the stalk of *Chunella*, there are siphonozooids in the stalk of *Calibelemnon*.

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The value of the first of these distinctions has already been discussed (p. 107). As regards the second all that can be said is that these small and probably degenerate spicules are very easily overlooked and even if proved by exhaustive research to be absent do not constitute a good generic character.

The third character is one which also requires a very careful investigation before it can be accepted as sound. The presence of siphonozooids in the stalk of many specimens of *Umbellula* cannot be demonstrated except by carefully prepared sections, they cannot be seen at all in the whole mount preparations cleared in oil. Similarly in *Chunella biflora* no trace of siphonozooids can be seen by ordinary methods but a series of sections has proved that, in the specimen investigated there are many widely distributed but small siphonozooids in this species. It is true that at present no siphonozooids have been proved to occur in the stalk of *Chunella gracillima* but until more specimens of this rare and beautiful species have been carefully examined it would not be safe to assert that they are entirely absent in that region.

Another supposed difference between the two genera must also be referred to. In the diagnosis of the Chunellidae, KÜKENTHAL and BROCH (1911 p. 270) state that there are two kinds of siphonozooids "sehr kleinen an den lateralen Kielfeldern und grösseren mit einem fadenförmigen Tentakel versehenen innerhalb der Polypenwirtel" and in the diagnosis of the genera *Calibelemnon*, BALSS (1910 p. 70) states that "Siphonozooide tentakellos, zahlreich zwischen den Polypen, nur auf den lateralen Flächen vorhanden".

The occurrence of siphonozooids between the autozooids of a whorl is sometimes very difficult to demonstrate and in *Chunella biflora* they can only be seen in stained sections. In this species they certainly are not larger than the siphonozooids that are found between the whorls on the sides of the rachis and are either rudimentary of degenerate. If we regard the very careful investigation of *Calibelemnon indicum* by BALSS as proving the absence of siphonozooids in the whorls of that species then again *Chunella biflora* is intermediate between *Chunella* and *Calibelemnon*.

The absence of tentacles in the siphonozooids is not a character upon which any reliance can be placed as we know, from the study of *Umbellula* that these very delicate structures are so often lost in preservation.

The general conclusion arrived at, therefore, is that *Chunella*, *Amphiacme* and *Calibelemnon* should be united into one genus *Chunella* (Kükenthal).

The genus *Scleroptilum* appears to me to be distinct but should be retained in the same family. I have had no opportunity of studying a specimen of this genus but the presence of spicules throughout the rachis is a character which alone clearly distinguishes it from the genus *Chunella*.

The family Chunellidae therefore, according to my view contains two genera: —

Chunella (Kükenthal) without spicules in the rachis.

Scleroptilum (Kölliker) with spicules in the rachis.

The diagnosis of the family may be reduced as follows: —

Slender Pennatulacea with autozooids, without calices, arranged in whorls of 2 to 4 individuals and in some cases with solitary autozooids between the whorls.

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Genus **Chunella** Kükenthal.

Chunella Kükenthal 1902. Zool. Anz. XXV, p. 302.
Amphianthus Kükenthal 1902. Zool. Anz., XXV, p. 303.
Amphiacme Kükenthal & Broch 1911. Valdivia Pennatulacea, p. 276.
Calibelemnon Nutting 1908. Hawaiian Alcyonaria. p. 562.
Prochunella Balss 1909. Münchener Pennatuliden. p. 426.
Calibelemnon Balss 1910. Japanische Pennatuliden. p. 70.

The amended definition of the genus would read as follows: —

Slender sea pens with the autozooids in two lateral rows on the sides of the rachis or in whorls of two, three or four individuals. Autozooids not retractile and without calices. Siphonozooids in lateral rows on the rachis between the whorls of autozooids. No spicules in the rachis. Axis quadrangular in the stalk and lower part of the rachis, frequently cylindrical above.

There are six species attributed to the genus: —
Chunella quadriflora Kükenthal; *Chunella gracillima* Kükenthal; *Chunella abyssorum* = *Amphiacme abyssorum* Kükenthal & Broch; *Chunella biflora* n. sp.; *Chunella indica* = *Calibelemnon indicum* Balss = *Calibelemnon symmetricum* Nutting = *Protocaulon indicum* Th. and H.; *Chunella Hertwigi* = *Calibelemnon Hertwigi* Balss.

They may be arranged according to the following system:

A. Distance between the whorls of autozooids over 20 mm.
  a. With 4 autozooids in a whorl . . . . . *Ch. quadriflora*
  b. With 3 autozooids in a whorl . . . . . *Ch. gracillima*
  c. With 2 autozooids in a whorl . . . . . *Ch. abyssorum.*

B. Distance between the whorls less than 10 mm.
  a. With siphonozooids in the whorls and with spicules in the stalk . *Ch. biflora*
  b. With no siphonozooids in the whorls and no spicules in the stalk
    1. Autozooids in regular pairs . . . . . *Ch. indica*
    2. Autozooids irregular . . . . . *Ch. Hertwigi.*

The first three species of this list constituting the group A have only been found in depths exceeding 818 metres and extend downwards to a depth of 1019 metres. *Chunella biflora* which is in many respects intermediate in character between group A and the other species, was found, in its typical form, at a depth of 216 metres but two smaller specimens were found in shallower water.

As regards the other two species it may be remarked that the specimens of *Ch. (Protocaulon) indicum* described by Thomson and Henderson (1906 (2) p. 85) in the Indian Ocean were found at a depth of 100 metres and those described by Balss from Japan at depths of 100—180 metres but the specimens described by Nutting under the name *Calibelemnon symmetricum* and referred, after examination by Balss, to this species were found at depths of from 150—1270 metres off the coast of Hawaii. *Ch. Hertwigi* was found at a depth of 100 metres off the coast of Japan.

Leaving out of consideration for the moment the specimens from Hawaii, it will be

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observed that the very long species with whorls of autozooids situated at great distances apart have been found only in very deep water (818 metres) the intermediate form in deep water (216 metres) and the shorter forms with whorls more closely set in shallower water still 100—180 metres. It might seem therefore that the elongation of the rachis is to some extent an adaptation to the condition of life in the abyss. As regards the specimens from Hawaii. These specimens were placed in a distinct genus and species by NUTTING 1908 (*Calibelemnon symmetricum*) and in the original description of the genus he states that the sarcosoma is "thick and fleshy". In this respect the genus appears to be different to *Chunella* but BALSS, having examined a specimen of NUTTING's species, declares that it is identical with the species described by THOMSON and HENDERSON as *Protocaulon indicum*, and that as the genus *Protocaulon* falls to the ground (see p. 96) its name should be *Calibelemnon indicum*. As we have at present a description of only one specimen (600 metres) of the Hawaiian collection the difficulties arising from this series as regards bathymetrical distribution cannot, fruitfully, be discussed.

1. *Chunella gracillima* Kükenthal. (Pl. I, figs 8 & 9; Pl. III, fig. 15).

Chunella gracillima Kükenthal 1902. Zool. Anz. Bd XXV, p. 302.
Chunella gracillima Kükenthal and Broch 1911. "Valdivia" Pennatulacea. Pl. XV, p. 272.

Stat. 18. 7°28′ S., 115°24′ E. Bali sea. 1018 metres. 2 Ex.

Of the two specimens of this species one is complete although broken across, the other is so greatly damaged that it is quite impossible to describe it in detail. The complete specimen was drawn (Plate III, fig. 15) and measured but not dissected at all, the damaged specimen afforded valuable material for histological examination. The complete specimen is considerably longer than any of the Valdivia specimens and shows a much greater number of whorls, but in spite of these and some other differences in detail it does not seem necessary to institute a new species.

Considering the great distance that separates the localities from which the specimens of this species were obtained, the surprising thing is that they are so much alike, and considering the great depth in which they were found and their extreme delicacy it is also surprising that they have come to hand in such good condition.

The complete Siboga specimen is 755 mm. in total length and shows 9 whorls of 3 autozooids. The largest of the Valdivia specimens was 580 mm. in length with four whorls of autozooids and the second specimen was 365 mm. with five whorls.

The whole colony is extremely slender. The thickest part of the stalk is only 1.75 mm. in diameter and of the rachis, midway between the seventh and eight whorls, 1 mm. in diameter. It is therefore even more slender than the largest Valdivia specimen.

The distal part of the rachis attenuates almost to a thread but ends in an oval knob about 1 mm. in diameter. The proximal end of the rachis passes gradually into the stalk but I have entirely failed to find any determinate point of demarcation between the two regions. At a guess, I should say that the stalk is about 200 mm. in length or a little less than $^1/_4{}^{th}$ the total length.

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The axis appears to be extremely brittle, unlike the Valdivia specimens which are said to be "very elastic", and unless the greatest care is exercised in removing it from the bottle it is liable to bend at an angle or break across.

The rachis. The terminal knob shows three shallow verrucae with a pit in the centre and it seems probable that they represent the beginnings of a terminal whorl of autozooids.

The whorls are situated as follows: —

1st	whorl	3	autozooids					47	mm.	from	the end
2nd	„	3	„	47	mm.	from	the 1st	92	mm.	„	„ „
3rd	„	2	„	54	mm.	„	„ 2nd	146	mm.	„	„ „
4th	„	2	aut. + 1 small one	50	mm.	„	„ 3rd	196	mm.	„	„ „
5th	„	3	autozooids	48	mm.	„	„ 4th	244	mm.	„	„ „
6th	„	3	„	53	mm.	„	„ 5th	297	mm.	„	„ „
7th	„	2	small ones	50	mm.	„	„ 6th	347	mm.	„	„ „
8th	„	2	+ 1 small one	48	mm.	„	„ 7th	395	mm.	„	„ „
9th	„	3	autozooids	50	mm.	„	„ 8th	755	mm.	„	„ „

Length of bare rachis 110 mm.? 555 mm. from the end
Length of stalk . . . . 200 mm.? 755 mm. „ „ „ .

The length of the spindle shaped swellings of the rachis on which the autozooids are situated is about 11 mm. in length and the breadth is about 3.5 mm. The larger autozooids are 4.5 mm. in body length and the tentacles about the same length (Pl. I, figs 8 & 9).

The autozooids. It is quite certain that the autozooids and the tentacles of both species of *Chunella* are very contractile although never retracted below the surface of the rachis, very little reliance can be placed on these measurements in preserved specimens. In some specimens the body wall is ringed showing that some contraction has taken place, in others it is smooth. The tentacles of the autozooids that are encrusted with mud are longer than those that are clean showing that contraction has, to some extent, been interfered with. Specimens distended with ripe gonads have longer autozooids in the preserved condition, than those in which the gonads are immature.

Siphonozooids are found on the dorsal side of the swellings of the rachis that bear the autozooids. They are irregularly arranged but leave a bare track in the middle (Plate I, fig. 9). These siphonozooids also extend on to the ventral side between the autozooids (fig. 8).

According to Kükenthal and Broch these siphonozooids bear a simple tentacle. This feature was not observed in any case in the Siboga specimens but it is quite possible that they were broken off in preservation. In sections these siphonozooids show a long straight stomodaeum. The mesenteries are very feebly developed but there appear to be two long mesenteric filaments connected with the stomodaeum of each siphonozooid.

I have not found the siphonozooids that Kükenthal and Broch have described in the lateral surface of the rachis between the whorls. Several microscopic preparations were made without result but it is nevertheless possible that they have been overlooked.

The axis in the region of the stalk is quadrangular 1.75 mm. across each face, with

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deep grooves between the angles. In the lower part of the rachis the grooves are not deep. In the upper part of the rachis the axis becomes cylindrical.

There are no spicules in any part of the rachis. In the stalk minute oval corpuscles of which the largest are about .015 mm. × .01 mm. are scattered about in the cortical layers.

In both specimens the base of the autozooids was filled with gonads. Sections of an autozooid of the damaged specimen proved it to be a female, the largest eggs being about 0.5 mm. in diameter.

2. *Chunella biflora* n. sp. (Pl. I, figs 2 & 4).

Stat. 167. 2° 35′ S., 131° 5′ E. Off W. New Guinea. 118 metres. 1 Ex.
Stat. 204. 4° 20′ S., 122° 58′ E. Buton Strait. 75—94 metres. 1 Ex.
Stat. 302. 10° 27′ S., 123° 28′ E. Off Timor. 216 metres. 13 Ex.

The thirteen specimens from Stat. 302 varied in total length from 53 mm. to 150 mm. Many of them were more or less damaged and it was impossible in such cases to determine the exact number of autozooids in the rachis.

In one specimen 135 mm. in length there was a subterminal pair of autozooids the rachis projecting beyond it as a fine point for a distance of 2 mm. and there were, altogether, nine pairs of autozooids the last (proximal) two pairs being smaller than the others. In the fifth pair the autozooids had a body-length of 2.5 mm. and the tentacles were 8 mm. in length. The distance between the pairs was uniformly 8 mm.

The stalk was estimated to be about 25 mm. in length. The diameter of the rachis mid-way between the third and fourth pair was 0.75 mm. and the greatest diameter of the stalk was 2 mm. In many of the other specimens there was observed a great deal more irregularity in the arrangement of the autozooids on the rachis, single autozooids occurring at irregular intervals between the pairs.

In another specimen that was perfect and 150 mm. in length the arrangement of the autozooids was as follows: —

At the distal extremity there was a small subterminal pair of autozooids; 9 mm. further down a second pair and 12 mm. further down a third pair. At a distance of 4 mm. from this a solitary autozooid; 12 mm. from this another solitary autozooid and 10 mm. from this a third solitary autozooid. Six mm. from this was a pair, 8 mm. further down another pair, 9 mm. further down again a pair. Then at a distance of 8 mm. a pair, another pair at a distance of 9 mm. and finally at a distance of 8 mm. two autozooids not quite opposite to one another.

There were thus, eight pairs and six solitary autozooids on the rachis. Very great care was taken to observe the rachis opposite the solitary autozooids in case an autozooid had been accidentally broken off. The absence of a scar in all cases proved that they were really solitary.

As regards the distal end of the rachis there was also considerable variation observed. In five specimens there was a pair of autozooids subterminal in position in three

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specimens there was a single autozooid subterminal in position, in one specimen there was a single autozooid without tentacles at the extremity apparently quite terminal in position.

Autozooids. The size of the autozooids is very variable in the preserved specimens some being much more contracted than others, some being distended with eggs others barren. By making a large number of measurements and comparing them I have estimated that in specimens 100 mm. in length the fully grown autozooids are about 3 mm. in body length by 1 mm. in diameter and that the tentacles are about 2 mm. in length.

Siphonozooids. The siphonozooids occur on the swellings of the rachis which bear the autozooids, in rows on the lateral surfaces of the rachis between the pairs of autozooids and on the stalk.

The siphonozooids of the lateral surfaces can be seen in some specimens without treatment but those at the base of the autozooids cannot be seen even in whole mounts stained and cleared in oil. The proof that siphonozooids do occur at the base of autozooids can only be obtained by the examination of series of sections.

The cavities in the rachis at the base of the autozooids in these specimens are so distended with gonads that the stomodaea of the siphonozooids become flattened against the superficial epithelium and this condition renders them very inconspicuous in whole mounts. In structure they seem to resemble the siphonozooids of the parts of the rachis between the pairs having a long siphonoglyph and very feebly developed mesenteries. I have found no evidence that they possess a tentacle.

In a series of sections through a part of the stalk a number of small siphonozooids were discovered.

Spicules. The spicules of the stalk are arranged in two irregular rows. A few large ones are oval in shape .025 × .02 mm., but the majority are not over .01 mm. in length. There are no spicules in other parts of the colony. The dissected specimen was a female, the largest eggs being .25 mm. in diameter.

Axis. In all cases the axis is quadrangular in section below, becoming cylindrical distally. Even in the largest specimen the deep grooves between the angles of the axis, that form such a conspicuous feature of the axis of *C. gracillima*, were not observed, the four sides being quite flat.

Colour. The colour of all the specimens is uniformly pale yellow.

The specimens from Stations 204 and 167 (Plate I, fig. 4) have a different appearance from those from Stat. 302. Although they are very short, the autozooids are as large or larger than those of the longer specimens from Station 302, they stand out at right angles to the rachis and seem to me to have suffered less mutilation in capture. In both specimens the base of the autozooids is distended with ripe gonads.

In both specimens there is a single sub-terminal autozooid with tentacles and of the usual form although a little smaller and not so distended with gonads as the autozooids lower down. The tentacles have a single row of pinnules on each side and in the specimens examined longer and shorter pinnules alternate regularly in each row.

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	Stat. 204.	Stat. 167.
Total length	35 mm.	62 mm.
Distance of 1st pair from the distal end . .	5 „	6.5 „
2nd pair from 1st pair	5 „	8 „
3rd pair from 2nd pair	5 „	8 „
4th pair from 3rd pair	4 „	6 „
5th pair from 4th pair	4.5 „	5 „
6th pair from 5th pair		5 „

Specimen from Station 204. The autozooids of the 2nd pair have a body length of 2.25 mm. and the tentacles are of about the same length. The diameter of the rachis between the 1st pair of autozooids and the distal end is 0.12 mm. The flesh was unfortunately torn off the stalk, but the diameter of the axis of the stalk is 0.25 mm.

Specimen from Station 167. The autozooids of the 3rd pair have a body length of 3 mm. with tentacles about 4 mm. in length. The diameter of the middle region of the rachis is 0.75 mm. and the diameter of the stalk 1 mm.

In this specimen, when still in spirit, the siphonozooids can be distinctly seen between the pairs of autozooids. On each lateral surface extending from the base of one autozooid to the base of the corresponding autozooid of the next pair there is an irregular row of 14 or 15 siphonozooids. Below the last pair of autozooids the tissues are more opaque and I cannot determine whether the siphonozooids extend further down.

This species resembles in some respects the *Amphiacme abyssorum* of KÜKENTHAL and BROCH (1911 p. 276) as the autozooids are usually arranged in pairs on the rachis. All the specimens that were collected however are smaller than any of the four specimens of KÜKENTHAL's species and have a greater number of pairs of autozooids for a given length of rachis.

The longest specimen of *Chunella* (i. e. *Amphiacme*) *abyssorum* was 392 mm. in length and the shortest 160 mm. in length. The longest specimen of *Chunella biflora* is 150 mm. in length and the shortest only 35 mm. Taking the two species together therefore there is a continuous series so far as the character of length is concerned from 35—392 mm. But when we come to consider the character of the number of pairs of autozooids there is a very definite break in the continuity between the Valdivia specimens and the Siboga specimens. In the former the number varies from 2 pairs in the smallest to 4 in the largest, whereas in the largest of the latter there are 8 pairs and the smallest 5 pairs.

It is possible that the difference between the two groups as regards length and numbers of pairs of autozooids may be correlated with depth of habitat, the Siboga specimens being found in shallow water (75—118 metres) and the Valdivia specimens in deep water (818—1019 metres) but still they are sufficient to justify their separation in distinct species.

A feature of special interest that the Siboga specimens from Station 302 show is the great variability of the arrangement of the autozooids. If these 13 specimens had been obtained from several localities there might have been some inclination to separate them into a number of distinct species but as they all came up in one haul of the dredge there can be no doubt that they are variants of one and the same species.

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The species seems to have some affinities with the *Protocaulon indicum* of THOMSON and HENDERSON (1906 (2) p. 85). KÖLLIKER's genus *Protocaulon* has been shown by JUNGERSEN (1904 p. 30) to be unsound, the type species being a young *Virgularia*. *Protocaulon indicum*, however, is not a young *Virgularia* as it has sexual organs in the fully developed autozooids. It is probable that BALSS (1910 p. 71) is correct in regarding the Indian species as identical with his species *Calibelemnon indicum* = *C. symmetricum* (Nutting).

It appears to me that the genus *Calibelemnon* can no longer be kept separate from *Chunella* but if it is a fact that there are no siphonozooids at the base of the autozooids the species *Chunella indicum* may be kept distinct from *Chunella biflora*. I am doubtful whether *Ch. (Calibelemnon) Hertwigi* of BALSS is a good species owing to the known variability of the arrangement of the autozooids in *Ch. biflora* but I am content to recognise it for the present (see p. 110).

Family UMBELLULIDAE.

As there is only one genus in this family the diagnosis and history of the family is that of the genus.

Genus **Umbellula** Cuvier.

Hydra marina arctica Ellis 1753. Trans. Roy. Soc. 48, p. 305.
Vorticella encrinus Linnaeus 1767. Systema Naturae. Ed. XII, p. 1317.
Ombellula Cuvier 1798. Tableau elementaire. p. 675.
Umbellularia Lamarck 1816. Anim. s. Vertèbres. 1st Ed. Vol. II, p. 436.
Umbellula Gray 1870. Catalogue of Sea-pens. p. 36.
Umbellula Kölliker 1875. Die Pennat. Umbellula p. 11.
Umbellula Kölliker 1880. "Challenger" Pennatulida. p. 16.
Umbellula Koren & Danielssen 1884. Norwegian N. Atlantic Exped. IV, p. 13.
Umbellula Thomson and Henderson 1906 (2). "Investigator" Alcyonaria. p. 92.
Umbellula Kükenthal and Broch 1911. "Valdivia" Pennatulacea. p. 175.
Umbellula Kükenthal 1914. Zool. Anz. Vol. 48, p. 630.

The first specimen of this genus was discovered by ADRIAANZ, Captain of the "Brittania", a whaling vessel engaged off the coast of Greenland in the summer of 1752.

There is a good description with several illustrations of this specimen by JOHN ELLIS in the Transactions of the Royal Society, Vol. 48, 1753, p. 305, and in the Natural History of the Corallines published by the same author in 1755 (p. 96). It was also described by CHR. MYLIUS in 1753.

ELLIS called it the "Hydra marina arctica" or Cluster polype and in comparing it with the "Encrinos" or "Lilium lapidem" of the palaeontologists gave good reasons for keeping it apart as a separate genus. It is referred to in the XIIth edition of LINNAEUS "Systema Naturae" (1767 p. 1317) under the name "Vorticella encrinus" and was named "Ombellula" by CUVIER in 1798. In MILNE-EDWARDS' edition of CUVIER's "Regne Animale" it is called "Ombellulaire" or *Umbellularia groenlandica*.

The next good description and figures are given by LINDAHL in 1874 of specimens obtained by a Swedish expedition in Baffin's Bay (740 metres) and this was followed four years

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later by a systematic description by KÖLLIKER (1875) of the older species and of a new one obtained by the "Challenger" expedition.

In the "Challenger" reports of the Pennatulida published in 1880, KÖLLIKER described several new species and recorded the important discovery that in two of these species *U. Huxleyi* and *U. Carpenteri* the siphonozooids possess a single tentacle.

In MARSHALL's (1883 p. 142) account of the Pennatulida of the "Triton" expedition there is an excellent account of the structure of these tentaculate siphonozooids.

In the more recent literature there is to be found a good description and systematic study of *U. encrinus* by KOREN and DANIELSSEN (1884 p. 13), of *U. encrinus* and *U. Lindahlii* by JUNGERSEN (1904) and descriptions of new species by THOMSON and HENDERSON (1906 (2)) and by KÜKENTHAL and BROCH (1911 p. 286).

The genus can be readily distinguished from the other genera of Pennatulids by the arrangement of all the autozooids in a tuft or tassle at the end of a very long stem. The morphology of this stem is not quite clear and there are differences of opinion as to its relations to the rachis or stalk of other Pennatulids. It is necessary therefore to explain the terms that are used in this memoir and to discuss the views that have been adopted.

In other Pennatulids (except *Virgularia*) there is usually a well marked boundary line between the rachis and the stalk and the former bears all the zooids of the colony, the latter none.

In *Umbellula* we can distinguish the following regions of the the pen (textfig. 28): —

1. A region at the distal extremity bearing the autozooids.
2. A region immediately following this, which gradually narrows below and usually bears numerous scattered siphonozooids. This passes gradually into: —
3. A very long slender region also bearing siphonozooids and gradually expanding below into: —
4. A thicker region with muscular walls and terminating below in: —
5. A short thin walled bulbous expansion.

Regions 1 and 2 clearly belong to the rachis. All the authorities seem to be agreed upon that.

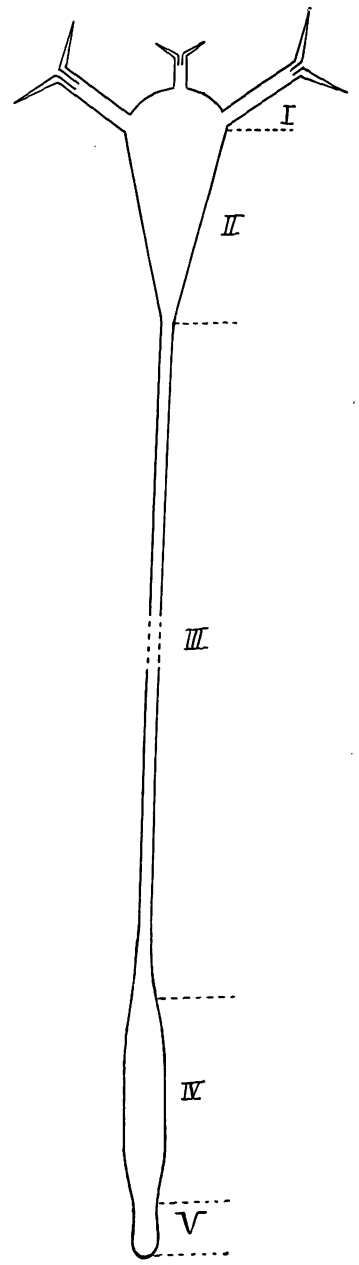

Fig 28.
Diagram of *Umbellula* to show the regions referred to in the text.

The discovery of numerous siphonozooids extending down the whole length of the 3rd region may be taken as a proof that this region is also a part of the rachis.

In some species however, (e. g. *U. Carpenteri* and *U. Lindahlii*) the siphonozooids extend on to the expanded fourth region, and in the former they extend almost to the proximal extremity [1]).

1) HICKSON 1907 (2) p. 13.

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JUNGERSEN was of opinion (1904 p. 82) that "the zooid-less part of the bulb corresponds to the peduncle (i. e. stalk) of other Pennatulids and the greater part of the stalk (i. e. stem) from the beginning is to be regarded as the rachis".

If we take arbitrarily the lower limit of the siphonozooids as the boundary line between rachis and stalk, *U. Carpenteri* has practically no stalk and our morphological conceptions are reduced to an absurdity. The point must be conceded that in the genus *Umbellula* siphonozooids may occur on the true stalk [1]).

In many species however the siphonozooids apparently stop short suddenly at a point marked by a dotted line between III and IV in the diagram. Above this point the stem is usually circular in section and a great deal thicker than it is in the middle region. Below this point it expands again and is usually marked, in preserved specimens, by four deep longitudinal grooves.

It is this point which in my opinion marks the boundary between rachis and stalk.

Unfortunately the rarity of these sea-pens renders it impossible at present to confirm this opinion by an appeal to structure and it must remain an opinion only until that appeal can be made; but that the greater part of the delicate stem or 3rd region of Umbellulids corresponds with the rachis and not with the stalk, appears to me to be rendered certain not only by the constant presence of siphonozooids but also by the absence of the elaborate muscular system which is so characteristic a feature of the stalk of other pennatulids.

It may be said that in some species siphonozooids have not been described in this third region of the rachis. That is true; but a very little experience is enough to convince any one that it is only by the examination of thin slices of the skin by the microscope that the presence or absence of siphonozooids can be proved, and the proof that they are absent is much more difficult than the proof that they are present.

I should not be surprised if it were proved eventually that siphonozooids occur spasmodically on the stalk in all species.

The first three regions of the pen therefore I regard as the rachis, the last two as the stalk.

The first region (the "Polypenträger" of KÖLLIKER) bears autozooids and siphonozooids.

The second region (the "rachis club" of JUNGERSEN) bears siphonozooids only.

The third region is usually very slender and bears siphonozooids in two or more longitudinal rows.

The fourth region is the upper region of the stalk (the "lower swelling of the stalk" of some authors) and may bear siphonozooids.

The fifth region is the lower swelling of the stalk or basal bulb and rarely (?) bears siphonozooids.

The difficulty of determining what are the most reliable characters for separating species is rendered more difficult in the case of *Umbellula* than in many genera of Pennatulids by the fact that with one exception of *U. encrinus* only a few specimens of a given species are known and our knowledge of the changes they undergo in growth is a negligable quantity.

The study of the magnificent work of KOREN and DANIELSSEN (1884 p. 13) on *U. encrinus*

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1) Siphonozooids have also been found on the stalk of of *Anthoptilum* p. 146.

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indicates that some of the characters that are used in the diagnostic description of the species are of little value.

For example; as regards the relative length of the stalk, we find that it varies from one-third of the total length in specimen 8 to one-tenth of the total length in specimen 4, and as regards the thickness of the third region of the rachis there is a variation from 0.5 mm. in specimen 1 to 4 mm. in specimen 4, and that specimen 4 with a total length of 154 mm. has a greater diameter in this region than specimen 10 with a total length of 1820 mm.

As regards the arrangement of the autozooids on the rachis, the separation of species according to a bilateral or irregular arrangement of the autozooids presents many difficulties and uncertainties. As KÖLLIKER pointed out the five specimens of *U. Carpenteri* collected by H. M. S. Challenger showed "a very interesting gradation from a bilateral to an apparently irregular arrangement of the polyps", and every one who has the opportunity of examining a number of specimens of the species will be certain to find cases in which it is difficult to determine whether the arrangement of the autozooids is or is not strictly bilateral.

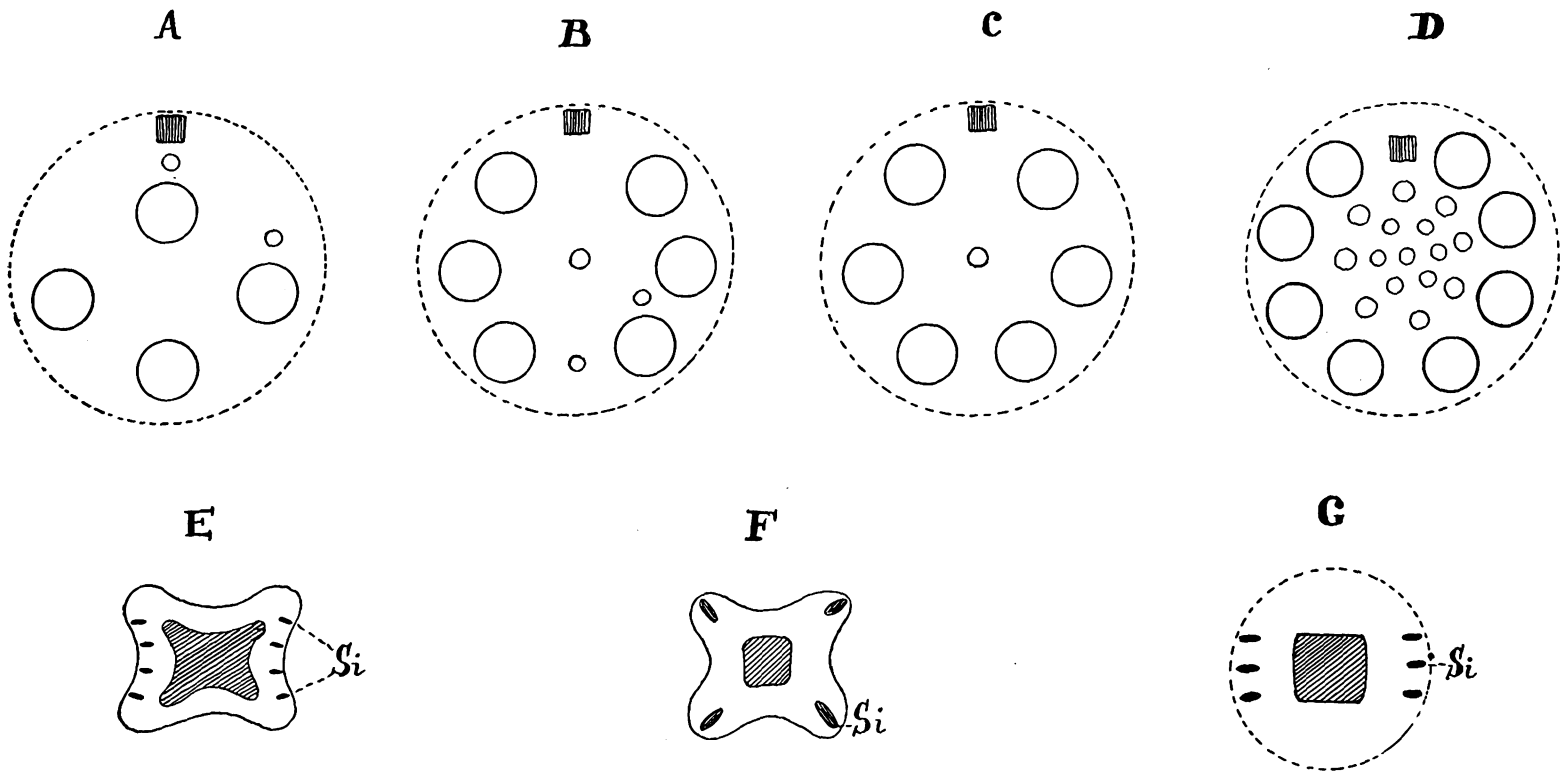

Fig. 29.

A. Diagram of the arrangement of the autozooids in the larger specimen of *Umbellula durissima*.
B. Diagram of the arrangement of the autozooids in specimen B of *Umbellula pellucida*.
C. Diagram of the arrangement of the autozooids in specimen A of *Umbellula pellucida*.
D. Diagram of the arrangement of the autozooids in *Umbellula Weberi*.
E. Diagram to show the arrangement of the siphonozooids (*Si*) in the third region of the rachis of *Umbellula antarctica*.
F. Diagram to show the arrangement of the siphonozooids (*Si*) in the third region of the rachis of *Umbellula durissima*.
G. Diagram to show the arrangement of the siphonozooids (*Si*) in the third region of the rachis of *Umbellula Weberi*.
The axis is shown by shading in all the figures.

The arrangement of the siphonozooids on the second region of rachis — (the rachis club) is obviously very variable and unreliable. Moreover the skin of this region is often so badly rubbed in the long journey from the bottom of the sea that their true arrangement is lost.

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KÜKENTHAL and BROCH (1911 p. 290) rely upon the absence of a tentacle on the siphonozooids as one of the two characters that separate *U. antarctica* from *U. encrinus* but this delicate structure is so easily broken off or rubbed off that it is not a good character to rely upon. In examining the first specimen of *U. antarctica* in the Siboga collection I thought at first that there were no tentacles on the siphonozooids and it was only when I made an examination of the siphonozooids that had been protected from injury by being situated in the grooves that I fouud them. Moreover the possibility of the retraction of the tentacle must not be lost sight of. KOREN and DANIELSSEN (1884 p. 40) point out that in *U. encrinus* the tentacle may be retracted and the siphonozooid in this case has all the appearance of a normal one without a tentacle.

It is quite probable that in all species of *Umbellula* some of the siphonozooids possess a tentacle and, at present, the statements that are made, that the tentacles are absent, must be regarded only as a guess unless they have been confirmed by the microscopic examination of sections.

One more character needs a few words of warning. In some species the pinnules of the tentacles of the autozooids have been found to vary in length. In *U. valdiviae* for example the pinnules are said to alternate in length.

In the second specimen of *U. antarctica* in this collection, however, I found that in some tentacles the pinnules were arranged along the edge alternately long and short, in others there were three short ones alternating with one long, in others two short ones for each long one and finally in a few others the pinnules were all approximately of the same size.

In other specimens (e. g. *U. Carpenteri*) I have noticed similar variations and I am quite convinced that this character is quite untrustworthy for specific distinctions.

There seems, however, to be a sharp distinction between the species which possess rod shaped spicules in the bodies and tentacles of the autozooids and those that do not, and on this character they may be divided into two groups.

The following species have spicules in the autozooids: —

U. aciculifera Thomson.	*U. eloisa* Nutting.	*U. intermedia* T. and H.
U. crassiflora Roule.	*U. Güntheri* Köll.	*U. leptocaulis* Köll.
U. dura T. and H.	*U. Thomsonii* Köll.	*U. rosea* T. and H.
U. durissima Köll.	*U. Hendersonii* T. and H.	*U. simplex* Köll.

The following species have no spicules in the autozooids: —

U. antarctica Kük.	*U. indica* T. and. H.	*U. purpurea* T. and H.
U. Carpenteri Köll.	*U. Jordani* Nutt.	*U. radiata* T. and H.
U. elongata T. and H.	*U. Köllikeri* Kük.	*U. rigida* Kük.
U. encrinus Kor. and Dan.	*U. Lindahlii* Köll.	*U. spicata* Kük.
U. geniculata Stud.	*U. loma* Nutting.	*U. valdiviae* Kük.
U. gracilis Marshall.	*U. magniflora* Köll.	*U. Weberi* Hickson.
U. Gilberti Nutt.	*U. pellucida* Kük.	
U. Huxleyi Köll.	*U. pendula* T. and H.	

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Of the species with spicules in the autozooids *U. durissima* and *U. eloisa* are distinguished from the others by the great size of these spicules.

A group consisting of *U. dura*, *U. Hendersonii*, *U. intermedia* and *U. rosea* from the Indian Ocean with smaller spicules in the autozooids are obviously closely related to one another and to *U. crassiflora*, *U. Güntheri* and *U. Thomsonii* from the Atlantic Ocean.

U. Güntheri recently described more fully by BROCH (1913 (1)) seems to be distinguished by its remarkable ridged and tuberculated spicules.

U. leptocaulis and *U. simplex* are probably quite young forms and not good species. The former I am inclined to believe, from the great size of its autozooids, is the young of *U. durissima*.

U. aciculifera has very small spicules in the autozooids and seems to be related to *U. Carpenteri* of the second group.

Of the species without spicules in the autozooids the characters that appear to me to be most useful for distinguishing species are: —

1. the number of the autozooids.
2. the size of the autozooids.
3. the relative length of the tentacles and the bodies of the autozooids.

The first two of these can only be used for specimens of a size that may be regarded as adult in character, i. e. 400 mm. or more in length.

For example, an *Umbellula antarctica* 460 mm. in length has 41 autozooids, an *U. Carpenteri* 485 mm. in length has only 9, and an *U. encrinus* 470 mm. in length has 17.

There is, it is true, a considerable increase in the number of autozooids with the increase in length and, probably, age. Thus in *U. encrinus* we have the following figures among others; — Specimens 580 mm. in total length, 13 autozooids; 1820 mm., 34 autozooids, (K. and B.) 2350 mm., 40 autozooids (JUNGERSEN). This number, therefore, can only be used in relation to length.

Similarly, there is probably some increase in the size of the autozooids with age and the measurements can only be used for specific purposes if the length of the colony is known. But some of the figures are very striking, for example in *U. antarctica* a specimen 500 mm. in length had autozooids with a body length of 24 mm., *U. pellucida* 338 mm. in length, autozooids 8 mm., *U. Weberi* 485 mm. in length, autozooids 11 mm.

In the following group specimens of 400—500 mm. in length have a large number of autozooids (30 or more), the autozooids having a body-length of 20 mm. or more.

U. antarctica.	*U. pendula.*	*U. radiata.*
U. indica.	*U. purpurea.*	*U. spicata.*

The largest specimen of *U. valdiviae* was 200 mm. and the species is related to *U. spicata.*

In the following group there are only a few autozooids (10 or 12) in specimens of 400 mm. in length.

U. Carpenteri.	*U. magniflora.*
U. Lindahlii.	*U. Jordani.*

Of these four species, *U. magniflora* has autozooids with long bodies (25 mm.); *U. Carpenteri*, *U. Jordani* and *U. Lindahlii* autozooids with shorter bodies (15—19 mm.).

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Umbellula encrinus and *Umbellula gracilis* seem to be intermediate in character between these two groups. Specimens of *U. encrinus* described by KOREN and DANIELLSEN of 470 mm. had 17 autozooids, of 580 mm. had 13, and of 2350 mm. described by JUNGERSEN had 40 autozooids.

A specimen of *U. gracilis* 547 mm. in length described by BROCH (1913 (1)) had 25 autozooids. The type specimen was 290 mm. in length with 15 autozooids.

As regards the body-lengths of the autozooids we find that in KOREN and DANIELLSEN's N° 6 specimen of *U. encrinus* 470 mm. in length the body-lengths were 12 mm., in N° 7 830 mm., 15 mm., and in N° 8 1480 mm., 35 mm. These figures taken at random indicate that the body-lengths of the autozooids as compared with the total length are shorter in *U. encrinus* than in the first group of species.

Of the remaining species that seem to be good the only known specimen of *U. Weberi* is 485 mm. in length with 30 autozooids and *U. loma* is 200 mm. in length with 10 autozooids. As regards *U. pellucida*, KÜKENTHAL and BROCH's largest specimen was 225 mm. in length and had 18 autozooids but the largest specimen in the Siboga collection was 338 mm. in length and had only 9 autozooids. This species, however, is distinguished from the others by the very short autozooids, 8 mm. in length.

As regards the relative lengths of the tentacles and the bodies of the autozooids: —

In *Umbellula encrinus* the tentacles are about the same length as the bodies of the autozooids. In *Umbellula Carpenteri*, *U. Lindahlii* and *U. Gilberti* they are usually much longer than the bodies but in one specimen of *U. Carpenteri* obtained by the "Discovery" expedition they were only half the length.

In *Umbellula antarctica*, *U. Jordani*, *U. Huxleyi*, *U. Köllikeri*, *U. magniflora*, *U. pellucida* and *U. Weberi* they are shorter than the bodies.

In *U. loma*, *U. pendula*, *U. rigida*, *U. spicata* and *U. valdiviae* they are longer than the bodies.

The spicules that are found in the stalk of these species of *Umbellula* do not unfortunately afford us good characters for specific determination.

Small oval calcareous spicules have been described in *U. antarctica*, *U. Carpenteri*, *U. encrinus*, *U. gracilis*, *U. Huxleyi*, *U. Köllikeri*, *U. Lindahlii*, *U. loma*, *U. pellucida*, *U. rigida*, *U. spicata* and *U. valdiviae*. In *U. elongata* it is stated that the spicules in the stalk are rods and four-cornered spicules. In *U. Gilberti*, *U. Jordani*, *U. magniflora*, *U. pendula*, *U. radiata*, *U. purpurea* and *U. Weberi* they are said to be absent.

The records however as regards these spicules do not appear to be wholly trustworthy. KÜKENTHAL and BROCH (1911) state that small oval spicules occur in all the species obtained by the "Valdivia" in the Indian Ocean. THOMSON and HENDERSON (1906 (2)) say there are none in their species of this group obtained from different localities in the Indian Ocean except in *U. elongata*. I failed to find spicules in the only specimen of *U. Carpenteri* that I have examined or in the species *U. antarctica*, *U. Jordani* and *U. Weberi*.

It is impossible to say whether this discrepancy is due to faulty observation, to the methods of preservation or to a real variability, but it is evident that these very minute

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corpuscles — never much larger than a blood corpuscle — cannot be relied upon at present for specific determination.

The recognised species without spicules in the autozooids may be arranged as follows: —

I. With a large number of autozooids (i. e. 40—50 in specimens of from 400—500 mm. in length) the autozooids being 20 mm. or more in body length.
   A. Tentacles much shorter than the bodies of the autozooids . . . *U. antarctica*
   B. Tentacles longer than the bodies. . . . . *U. spicata.*

II. With an intermediate number of autozooids (i. e. 15—40 in specimens 400—500 mm. in length)
   A. With a cylindrical axis . . . . . *U. gracilis*
   B. With a quadrangular axis . . . . . *U. encrinus*, *U. Weberi.*

III. With a small number of autozooids (i. e. 8—15 in specimens 400—500 mm. in length.
   A. With tentacles longer than the bodies. . . . . *U. Carpenteri*, *U. Lindahlii*, *U. loma.*
   B. With tentacles shorter than the bodies. . . . . *U. Jordani*, *U. magniflora*, *U. pellucida.*

A number of species from the Indian Ocean have been described which seem to have the same characters, so far as this table is concerned. The names given to them are; *U. spicata* and *U. valdiviae* Kükenthal and *U. indica*, *U. pendula*, *U. purpurea*, *U. radiata* Thoms. and Henders. In my opinion they are all varieties of one species and the name *U. spicata* claims priority.

Unfortunately there are no illustrations of *U. indica*, *U. pendula* and *U. radiata* and the measurements of tentacle-lengths and the exact number of autozooids are not recorded, but Kükenthal and Broch consider their *U. spicata* to be related to *U. pendula* and *U. spicata* is also closely related to *U. valdiviae.*

Umbellula elongata (Th. & H. 1906 (2) p. 96) differs from other species in having rod-shaped and four cornered spicules in the stalk but the number of the autozooids is not given by the authors.

The following species appear to have been founded on young specimens and their affinities are doubtful: —

U. Huxleyi, probably related to *U. magniflora.*

U. Gilberti, *U. Köllikeri* and *U. rigida*, probably related to *U. Carpenteri.*

The preliminary description of *U. geniculata* by Studer (1894 p. 58) is not sufficient to indicate its affinities.

The species *U. Lindahlii* was considered by Jungersen to include the following species of previous authors. *U. miniacea* and *U. pallida* of Lindahl, *U. Lindahlii* of Kölliker, *U. gracilis* of Marshall and *U. Bairdii* of Verrill.

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Umbellula gracilis however obtained by the "Triton" expedition in 552 fathoms off the N. W. coast of Scotland and by the "Michael Sars" expedition off the Canaries has a larger number of autozooids in comparison to its length, the tentacles are not longer than the body length, and the axis is cylindrical (BROCH 1913 (1) p. 6).

Moreover, the pinnate tentacles of the siphonozooids in this form have not been described in any other species. It is quite possible therefore that *U. gracilis* may after all prove to be a good species (cf. BROCH 1913 p. 6).

The specimen of *Umbellula Carpenteri* that I described (in 1907) from the Antarctic ice barrier in 300 fathoms differs from the other specimens of the species in several particulars. It is of much greater length (700 mm.), the bodies of the autozooids are much longer and the tentacles are shorter, not longer, than the bodies of the autozooids. The specimens attributed to this species by JUNGERSEN (1907) obtained by the "Belgica" expedition in 2800 metres near the Antarctic pack ice were much smaller.

Unfortunately the "Discovery" specimen was destroyed in a fire that broke out in my laboratory and I cannot refer to it again but it is possible in the light of modern research that this specimen may represent a distinct species.

A different arrangement of the species of *Umbellula* has recently been suggested by KÜKENTHAL (1914 p. 630) but it does not appear to me an improvement on the one suggested above as it relies too much upon the shape of the axis which I believe will prove to be a very variable character.

Geographical distribution. In the following list I have given the distribution, so far as it is known at present, of all the species of *Umbellula* that have been described: —

I. Indian ocean species with spicules in autozooids: — *U. dura*, *U. Hendersonii*, *U. intermedia*, *U. rosea*.

II. Indian ocean species without spicules in the autozooids: — *U. indica*, *U. Köllikeri*, *U. pendula*, *U. purpurea*, *U. radiata*, *U. rigida*, *U. spicata*, *U. valdiviae*.

III. Pacific ocean species with spicules in the autozooids: — *U. eloisa*, *U. leptocaulis*, *U. simplex*.

IV. Pacific ocean species without spicules in the autozooids: — *U. geniculata*, *U. Gilberti*, *U. Jordani*, *U. loma*.

V. Atlantic ocean species with spicules in the autozooids: — *U. crassiflora*, *U. Güntheri*, *U. Thomsonii*.

VI. Atlantic ocean species without spicules in the autozooids: — *U. encrinus*, *U. Lindahlii*.

VII. Malay archipelago species without spicules: — *U. Weberi*.

VIII. Cape of Good Hope species with spicules: — *U. aciculifera*.

The following species have a wider distribution: —

U. durissima: — N. Pacific, Malay archipelago, Indian Ocean and Antarctica.
U. Güntheri: — Atlantic and Pacific.
U. antarctica: — Antarctic and Malay archipelago.
U. Carpenteri: — Antarctic and Pacific.
U. pellucida: — Indian Ocean and Malay archipelago.

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U. Huxleyi: — N. Pacific and Indian Ocean.
U. magniflora: S. Atlantic and Pacific.

A specimen of *U. encrinus* was described by STUDER (1894 p. 57) from the Pacific Ocean but this is regarded as a distinct species by JUNGERSEN.

As regards the bathymetrical distribution two points of general interest may be mentioned.

All the species with spicules in the autozooids are typically very deep sea forms. All the records are from water of a greater depth than 1000 fathoms (1828 metres) except five; *U. durissima* (two specimens from Malay archipelago 567 metres and one specimen from Japan 564 fathoms), *U. eloisa* 600 fathoms, *U. dura* 705 fathoms and *U. aciculifera* 100—900 fathoms.

The species without spicules in the autozooids are more typically found in water of less than 1000 fathoms.

U. Carpenteri is found in depths of 300—1975 fathoms in the antarctic seas and *U. magniflora* in depths of 245—1600 fathoms but the other species have only been found in depths of less than 1000 fathoms. *Umbellula encrinus*, of which we have the best knowledge, extends from 105—760 fathoms but other comparatively shallow records are *U. pendula* 220 fathoms and *U. antarctica* 310 metres.

Natural History. Very little is known about the natural history of these Pennatulids. ELLIS [1]) suggested that the second region of the rachis acted like the swimm bladder of fishes, but it seems probable that they all live in an upright position with the stalk or a part of the stalk embedded in the mud.

It is true that in some cases it is stated that the bottom from which they were taken was "hard ground" but the occurrence of siphonozooids on the stalk is not inconsistent with a life in soft mud.

When seen alive all the Umbellulas seem to have a red or red-brown colour, but this colour disappears in the preservatives. It would be very interesting to compare this soluble colouring matter with Pentacrin and other colouring matters of Crinoids and Gephyrea.

Note on *Crinillum Siedenburgii*. In the year 1858 the officers of Z. M. brig Cachelot were sounding in the great depths of the Banda Sea and obtained a specimen of which a rough coloured drawing and description was given in the Journal of the Expedition and a discussion of the affinities of the specimen published in the Proceedings of the Academy of Sciences of Amsterdam (1861 p. 286). The external form of this remarkable specimen resembles that of an *Umbellula* and the whorl of autozooids (Polypenhoofd) at the distal end was 50 mm. in length and 25 mm. in breadth. VAN DER HOEVEN and his colleagues regarded the five lobes of the head as the tentacles of a single polyp but I am inclined to think that they represent the bodies of five autozooids from which the tentacles have broken off. Whatever may be the interpretation of this drawing of the head, the details of the structure of the stem render it almost certain that it was an *Umbellula*.

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1) The following passage from ELLIS' memoir (1755 p. 97) is of interest in this connexion: —
"This Bladder seems calculated, as well to raise or sink the Animal at pleasure in the Sea, like the swimming Bladder of Fishes as to convey by this Chanel the necessary Materials which the several different Bodies collect for the Support and Increase of the long bony Stem, a Part that seems to be of the highest Importance to the Preservation and Well-being of this extraordinary compound Animal".

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The exact locality and depth of this find are given as 6°40′ S. and 126°47′ E. (2700 fathoms) 4937 metres. This is about 58′ due South of the Lucipara islands (Siboga station 225) but no specimens were found by the recent dutch expedition in this neighbourhood.

Genus **Umbellula** Kölliker.

1. *Umbellula durissima* Kölliker. (Pl. X, fig. 77 & Textfigs 29 A & F).

Umbella durissima Kölliker 1880. "Challenger" Pennatulida. p. 16, Pl. VIII, figs 32, 33.
Umbella durissima Thomson and Henderson 1906. "Investigator" Alcyonaria. p. 92.
Umbella durissima Thomson and Ritchie 1906. "Scotia" Alcyonaria. p. 859.

Stat. 173. 3°27′ S., 131°0′ E. Near Ceram. 567 metres. 2 Ex.

The characteristic feature of this species, the large calcareous spicules of the body wall and of the tentacles of the autozooids, can be seen at once without the aid of a magnifying glass. The autozooids forming a cluster at the upper extremity of the rachis are few in number but of great size. The siphonozooids on the enlarged upper part of the rachis are numerous and prominent and those on the lower and narrow part of the rachis are arranged in four definite rows corresponding with the angles of the quadrangular rachis (Textfig. 29. F p. 119). The general appearance of this species is robust.

Of the two specimens in the collection the one which is called A is the larger and has four fully developed, with two smaller undeveloped, autozooids, and the other, which is called B, is the smaller and has four autozooids of smaller size than those of A.

Description of specimen A.

The total length is 485 mm., and of this about 108 mm. may be attributed to the stalk.

The uppermost, or first region, of the rachis, bearing the autozooids is 22 mm. in length, the middle region is 35 mm. in length and the dorsal side is marked by a ridge indicating the position of the axis. The third or slender region is about 270 mm. in length, quadrangular in section with a minimum thickness of 1.2 mm. The lower part of this region for a distance of 50 mm. gradually assumes a greater thickness and becomes circular in section.

The stalk consists of a long thick-walled deeply grooved swelling nearly 100 mm. in length with a maximum diameter of 4.75 mm. and a soft-walled terminal swelling 10 mm. in length and 4 mm. in diameter.

The autozooids are very large — the largest alcyonarian polyps I have seen, and are arranged as follows: one large autozooid is dorsal, one large one ventral and two large ones lateral, one small one near the base of the left lateral autozooid and one small one on the dorsal surface below the large dorsal autozooid (Textfig. 29. A p. 119). They are marked externally by eight deep groves. The largest autozooid has a body 30 mm. in length and about 7 mm. in diameter with tentacles 20 mm. or more in length making a total length of 50 mm. or about 2 inches.

The siphonozooids are very numerous and scattered on the second region of the rachis below the autozooids. They are indicated by short wart-like processes on the surface

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giving it a very rough appearance. They extend between the autozooids to the upper region of the rachis.

Where the rachis narrow below to form the third region they are arranged in four definite rows on the angular projections of the rachis (Textfig. 29. F. p. 119). These four rows are maintained as far down as the lower part of the third region of the rachis where they again become scattered.

No tentacles have been seen on any of the siphonozooids.

The spicules. Spicules are found on the body wall of the autozooids and on the abaxial surface of the axis of the tentacles. They may be divided roughly into two categories the large and the small.

The large spicules of the tentacles are rods with swollen extremities and attain to a magnitude of 3.4 × 0.26 mm. (Pl. X, fig. 77). The small spicules are also rod-shaped but do not show such well marked swollen extremities and the measurement of some of the larger ones of this group gives a magnitude of 0.34 × 0.04 mm. It is possible that the smaller spicules represent a stage in the growth of the larger ones. The spicules appear to be circular in section, i. e. they are rods and not flattened plates, and the surface is very rough; this roughness of surface being due to irregular rows of dentate edges.

Spicules are present in the stalk similar in shape to the smaller spicules of the tentacles but not so large (0.2 × 0.02 mm.) and in addition to these there are elliptical spicules of various sizes attaining to a magnitude of 0.11 × 0.037 mm. and a few quadriradiate forms similar to those described by THOMSON and HENDERSON in *U. dura*.

The colours are as follows: Autozooids bluish grey with tentacles of a light brown colour, the slender (third) region of the rachis pale yellow basal region of the stalk brown.

Specimen B.

This specimen has a total length of 285 mm. There are four autozooids having a total length of about 28 mm. the bodies being about 18 mm. and the tentacles 10—12 mm. in length.

The siphonozooids are arranged in four rows along the edges of the slender region of the rachis as in Specimen A but at much greater distances apart.

The type specimen of this species was obtained by the "Challenger" expedition in the North Pacific Ocean 1033 metres and described by KÖLLIKER (1880). It was evidently a much younger and smaller form, having only a single fully developed autozooid and a total length of 150 mm. The largest spicules were 2.85 mm. in length. KÖLLIKER does not mention in his description the character which appears to me to be one of the most interesting features of the species; namely the arrangement of siphonozooids in four well defined rows on the slender portion of the rachis.

Twenty specimens were obtained by the Scotia expedition from 3185 metres of water at 48°06′ S. and 10°5′ W. and described by THOMSON and RITCHIE (1906 p. 859). One of these specimens has as many as 9 autozooids. The largest autozooids were only 15 mm. in length × 8 mm. in breadth with tentacles 15 mm. in length.

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There is, therefore, a striking difference between the size of the largest autozooid of the *Umbellula* of the Scotia collection and that of the largest autozooid of the Siboga specimen A which was 30 mm. in length 7 mm. in diameter with tentacles 20 mm. in length.

The largest spicules in the specimens of this collection are said to be 2.5 × 0.25 mm.

The single specimen of the species described by THOMSON and HENDERSON from the Laccadive archipelago, 2070 metres, had four autozooids with an average length of only 9.75 mm. with tentacles 11.3 mm. in length.

I have very little doubt that the *U. eloisa* of NUTTING (1912 p. 43) from 1097 metres off the coast of Japan is closely related to this species. It is 730 mm. in length and has no less than 14 autozooids.

In the size of the autozooids it approaches the larger Siboga specimen and in the number of autozooids, the specimen with 9 autozooids obtained by the Scotia expedition.

A point of interest connected with the Siboga specimens is that they were found in comparatively shallow water, 567 metres or approximately 307 fathoms. The type specimen was found by the Challenger in 565 fathoms off the S. coast of Japan but most of the known specimens of the species were found in water of over 1000 fathoms.

2. *Umbellula antarctica* Kükenthal. (Pl. III, fig. 20 and Textfig. 29 B).

Umbellula antarctica Kükenthal 1902. Zool. Anz. Bd 25, p. 596.
Umbellula antarctica Kükenthal and Broch 1911. "Valdivia" Pennatulacea. p. 286, Pl. XV, fig. 15.

Stat. 17. 7°28′ S., 115°28′ E. Bali Sea. 1060 metres. 1 Ex.
Stat. 211. 5°40′ S., 120°45′ E. Near Saleyer. 1158 metres. 1 Ex.
Stat. 254. 5°40′ S., 132°26′ E. Near Kei Islands. 310 metres. 1 Ex.

As the three specimens that I have included in this species present some difference in detail they will be described separately.

The first specimen from Station 254.

The total length is 745 mm. The uppermost or 1st region of the rachis bearing the autozooids is 24 mm. in length, the second region is 65 mm. in length and the third region may be reckoned to be about 440 mm. in length and 2 mm. in thickness at its narrowest part.

It is very difficult to determine in this specimen where the rachis ends and the upper part of the stalk begins, because there is no abrupt swelling of the rachis below and because the two lateral rows of siphonozooids become very obscure as the stalk is approached and it would be impossible to determine where they actually cease without making a series of microscopic preparations.

The upper thick-walled part of the stalk is markedly quadrilateral, about 200 mm. in length and about 4 mm. in thickness. The basal swelling is about 17 mm. in length.

The autozooids are so numerous and crowded together that they are very difficult to count but it may be said that there are about 62 of them. (Compare Spec. 2, Plate III, fig. 20). They seem to be arranged in concentric circles but the circles are by no means very regular or well defined. In the outer circle there are 11 autozooids as in the type. In the centre of the bunch there is one zooid much shorter than the others, which may be regarded as the terminal autozooid.

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The autozooids. The total length of the autozooids of the outer circle is 35—38 mm. and the diameter 3—3.5 mm. Of the total length 24—26 mm. consists of the body and 10—12 mm. of the tentacles.

The siphonozooids are very numerous and scattered all round the second region of the rachis. At a distance of about 60 mm. from the outer circle of autozooids, they divide into two rows which appear to correspond with the lateral surfaces of the rachis. The dorsal and ventral surfaces are free from siphonozooids. These two rows of siphonozooids can be clearly seen extending right down the rachis to the stalk (Fig. 29. E. p. 119).

It may be observed, that these rows of siphonozooids correspond not with the angles of the rachis, as in *Umbellula durissima*, but with the grooves between the angles. The siphonozooids in certain grooves and furrows of the rachis where they have been protected from friction exhibit a short delicate tentacle without pinnae. They are arranged in various positions as regards the axis sometimes parallel with and sometimes at right angles to it.

There are no spicules in the autozooids and no spicules have been seen in other parts of the colony.

Colour. The rachis and autozooids are pale grey and the pinnules of the tentacles, light brown. The stalk is straw coloured and the basal swelling light brown.

2nd specimen from Station 17 (Plate III, fig. 20).

Total length about 878 mm. and of this about 138 mm. may be attributed to the stalk. This is the longest *Umbellula* in the collection. The upper swelling of the stalk in this specimen passes into the lowermost region of the rachis without any marked diminution of its diameter but the position where the siphonozooids stop can be determined with much greater certainty.

The uppermost region of the rachis bearing the autozooids is 40 mm. in length i. e. much longer than it is in the first specimen, the second region is 40 mm. in length and the third region is about 600 mm. in length with a minimum diameter of 2 mm. This part of the rachis is decidedly quadrangular in the middle but higher up it becomes almost cylindrical.

The upper region of the stalk is about 128 mm. in length with a greatest diameter of 8 mm. The basal swelling is about 12 mm. in length and 9 mm. in diameter. The upper region is quadrangular with four deep grooves in the preserved specimen.

Autozooids. There are about 52 autozooids arranged in somewhat irregular concentric circles, of which the outermost circle contains 8 individuals.

The total length of the autozooids is 30—34 mm. of which the bodies are 20—23 mm. and the tentacles 10 mm.

The siphonozooids are very numerous on the second region of the rachis and evenly distributed. On the third region they are arranged on two surfaces of the quadrilateral part and become evenly distributed again where the rachis becomes cylindrical. Some of the siphonozooids possess a single non-pinnate tentacle as in specimen 1.

In the elongated form of the uppermost region of the rachis this specimen seems to approach *U. spicata* of KÜKENTHAL but it differs from this species in the relative length of the tentacles. It also approaches in some respect *Umbellula valdiviae* of the same author but differs

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from it in the fact that the autozooids do not exhibit a bilateral arrangement and the siphonozooids occur in two definite stripes down the sides of the 3rd region of the rachis.

In this specimen a number of large ova are found loose in the body cavity and in the tentacles. They are oval in shape over 1 mm. in length with a germinal vesicle 0.15 mm. in diameter. Not one of those in my sections shows stages of development and it is improbable, therefore, that the species is viviparous.

The 3rd specimen from Station 211.

The total length of this specimen is 500 mm. of which about 87 mm. may be attributed to the stalk.

The uppermost region of the rachis bearing the autozooids is 23 mm. in length, the second region is 30 mm. in length and the third region is about 360 mm. in length with a minimum thickness of 1.75 mm. It is quadrangular in section with not very deep grooves.

The stalk consists of an upper swelling about 75 mm. in length and 7.5 mm. in diameter, quadrangular in section with four deep longitudinal grooves and a basal bulb 12 mm. in length and about 5 mm. in diameter.

Autozooids. There are about 32 autozooids arranged in four circles of which 8 occur in the outermost circle. The total length of the autozooids is 33 mm. of which 22—24 mm. may be attributed to the bodies and 12 mm. to the tentacles. The bodies are about 3 mm. in diameter.

The siphonozooids are arranged on the second part of the axis in spindle-shaped areas and pass upwards into the spaces between the autozooids. As the areas approach the third part of the rachis they become arranged in two stripes which can be traced some distance down this very slender part towards the base. Of these two stripes one is broader and bears more siphonozooids than the other. Still further down where the third part of the rachis swells to join the upper part of the stalk the siphonozooids are evenly distributed all round the rachis.

This specimen approaches more closely the description of the type given by KÜKENTHAL than any of the others in the arrangement of the siphonozooids in spindle shaped areas on the second region of the rachis and in having more siphonozooids on one side of the third region of the rachis than in the other. Judging from the number of the autozooids and the total length it is probably younger than the other two, and this may, as suggested above, account for the difference in the arrangement of the siphonozooids on the second region. On the other hand it differs from the type in its very slender form.

The only specimens hitherto obtained of this species are those described by KÜKENTHAL (1902) from off the Antarctic island Buvet in 457 metres (see KÜKENTHAL and BROCH 1911, p. 286, Pl. XV).

The first Siboga specimen is much larger than any one of the three Valdivia specimens, the longest of the latter being 465 mm. with 45 autozooids as compared with the Siboga specimen 745 mm. with 62 autozooids.

The principal difference between the Siboga specimens and the description of the type

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is in the arrangement of the siphonozooids on the rachis. KÜKENTHAL and BROCH (p. 286) say that "Die Zooide stehen am polypenfreien Kielteil in langgestreckten, spindelförmigen, aneinander gereihten Feldern" and on the under side of the rachis extend down the dorsal and particularly, the ventral sides. They do not state how many of the spindle-shaped areas are present in their specimens but assuming that the Siboga specimen is older than the Valdivia specimens it may be that the difference between them can be accounted for on the supposition that their spindle-shaped areas have become confluent in the older form.

A point of considerable importance, however, is that below the swollen part of the rachis the siphonozooid tracks are arranged in only two tracks. My interpretation of these tracks is that they are lateral in position whereas KÜKENTHAL and BROCH regard them as dorsal and ventral. As it is impossible to confirm my view by making the requisite number of microscopic preparations I do not wish to lay stress on this difference of opinion. In any case the difference between *U. antarctica* and *U. encrinus* in respect of the arrangement of the siphonozooids on the rachis is a striking one.

Another point of difference is that in our specimen some of the more protected siphonozooids show a single non-pinnate tentacle. KÜKENTHAL and BROCH state that in their specimens the siphonozooids had no tentacle. This difference may however be but a difference in the state of preservation of the specimens as it is quite certain that these delicate tentacles are very readily destroyed.

A comparison of the measurements of the three specimens of *Umbellula antarctica*.

	Specimen 1.	Specimen 2.	Specimen 3.
Total length	745 mm.	878 mm.	500 mm.
Length of stalk	217 „	138 „	87 „
First region of rachis	24 „	40 „	23 „
Second „ „ „	65 „	40 „	30 „
Third „ „ „	440 „	600 „	360 „
Minimum diameter of 3rd region	2 „	2 „	1.75 „
Number of autozooids	62	52	32
Length of bodies of autozooids	24—26 mm.	20—23 mm.	22—24 mm.
Length of tentacles of autozooids	10—12 „	10 „	12 „
Diameter of autozooids	3—3.5 „	3—3.5 „	3 „

3. *Umbellula Weberi* n. sp. (Pl. IV, fig. 24 and textfig. 29 D & G).

Stat. 18. 7°28′ S., 115°24′ E. Near Bali. 1018 metres. 1 Ex.

The characteristic feature of this species as compared with the other specimens of the collection is the very much flattened and spirally twisted second region of the rachis. This is not by itself a good specific character as it is known, by the researches of KOREN and DANIELSSEN (1884), that in *Umbellula encrinus* there is considerably variation in this respect within the range of a single species. The species is further characterized by the thick tuft of rather small

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autozooids, by the very long slender and cylindrical third region of the rachis and by the arrangement of the siphonozooids on two sides of this region (Textfig. 29. G. p. 119).

The total length of the specimen is 485 mm. The uppermost region of the rachis is 8 mm. in length and bears about 30 autozooids arranged in three circles with three or four smaller autozooids in the centre. The autozooids are so crowded together and so brittle in this unique specimen that I have refrained from the attempt to count them accurately.

The second region of the rachis is very much flattened and spirally twisted as in some specimens of *Umbellula encrinus* and *U. Lindahlii*. It is about 60 mm. in length. The axis can be clearly seen through the skin on the outer edge of the spiral (Plate IV, fig. 24).

The third region of the rachis is about 430 mm. in length with a minimum diameter of 1 mm. Unlike the other species in the collection this region is perfectly cylindrical in shape, notwithstanding the fact that the axis appears to be quadrangular in section with flattened sides.

The stalk is 90 mm. in length and the basal bulb very short and ill-defined. The upper region of the stalk is about 3 mm. in diameter and does not exhibit the longitudinal grooves seen in other species and the basal bulb is about 2 mm. in diameter.

The autozooids are about 30 in number and appear to be arranged in three concentric circles with the outermost circle consisting of 8, the next of 8, and the next to that of 6; of the remaining six autozooids standing within the inner circle one small sized individual may represent the terminal autozooid and the others which are also rather undersized are scattered irregularly around it. The bodies of the autozooids of the outer circles are 11 mm. in length and 2.75 mm. in diameter and their tentacles are about 3 mm. in length (Textfig. 29. D. p. 119).

The tentacles appear to be injured and contracted and probably somewhat longer in the natural state than the measurement given above.

The siphonozooids may be seen in great numbers projecting from the surface of the second region of the rachis as small hemispherical tubercular swellings. In some places they appear to be arranged in transverse rows but the rows are nowhere wide enough apart to constitute definite bare tracks. From this region siphonozooids extend upwards between the autozooids.

On the slender cylindrical third region of the rachis the siphonozooids are arranged in a very characteristic fashion (Textfig. 29. G. p. 119). When examined with a binocular microscope three delicate parallel lines may be seen running down each of the two sides of the cylindrical rachis and at intervals of 3 or 4 mm. minute siphonozooids occur on each side of these six lines. These siphonozooids are much smaller than those on the second region and do not project above the general surface of the skin.

On the upper region of the stalk the siphonozooids are of the same type but evenly scattered all round it.

No spicules were found in any part of the rachis or stalk.

The axis is, in the parts I examined, quadrangular with very rounded edges, but may become almost cylindrical in the most slender part of the rachis. A further examination of the axis could not be made without unnecessary damage to the unique specimen.

The colour of the first part of the rachis and the autozooids is adult pale brown, of the other parts of the rachis and stalk a straw-colour.

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U. Weberi appears to be most closely related to *U. encrinus* of the North Atlantic Ocean, but it is a more slender form with smaller and more numerous autozooids. The tentacles also are shorter than those of *U. encrinus* and there are no deep grooves in the axis.

A short diagnosis of the species based on this single specimen may read as follows: — *Umbellula* of slender habit, without spicules, with about 30 small autozooids in a specimen 485 mm. in length. Tentacles of the autozooids shorter than the body lengths. Axis quadrangular with rounded edges to cylindrical, without grooves. Malay Archipelago.

4. *Umbellula Jordani* Nutting.

Umbellula Jordani Nutting 1908. Hawaiian Alcyonaria. Proc. U. S. Nat. Mus. 34, p. 564.

Stat. 211. 5°40′ S., 120°45′ E. Off S. Celebes. 1158 metres. 1 Ex.

The total length of this specimen is 420 mm. and of this about 57 mm. may be attributed to the stalk.

The uppermost region of the rachis is about 10 mm. in length, the second region, sharply keeled by the axis is 23 mm. and the third region, very slender with a minimum width of 0.75 mm. is quadrangular in section and about 330 mm. in length.

The stalk consists of a very small basal bulb 2.5 mm. in diameter and not more than 4 mm. in length. The upper swelling 53 mm. in length does not exceed 2.8 mm. in diameter and passes gradually into the 3rd region of the rachis. It is deeply grooved on four sides.

There are no spicules in the rachis and no calcareous corpuscles were found in the stalk.

The autozooids are eight in number and of these seven stand in an irregular circle around a single short central autozooid. The central autozooid is 5 mm. in length but it has lost its tentacles. The total length of the remaining autozooids is 27—35 mm. and the diameter of each one about 2 mm. The length of the bodies of the autozooids is 17 mm. and of the tentacles 13—18 mm.

The siphonozooids are numerous on the second region of the rachis and extend between the bases of the autozooids. The siphonozooids in this specimen appear to be arranged more regularly in longitudinal lines than in any other that I have observed. I have not succeeded in finding any siphonozooids on the slender third region of the rachis or on the swollen basal regions of the stalk. Each siphonozooid bears a single tentacle and this tentacle has long pinnae and there are clearly dorsal mesenteric filaments.

This specimen resembles very closely the specimen described by Nutting as *U. Jordani* from 786—1420 metres off Hawaii. It is of approximately the same size, has the same number of autozooids arranged on the rachis in a similar way, and the measurements of the autozooids and tentacles are approximately the same.

It differs from *U. Huxleyi* in the character of the siphonozooids on the rachis. In *U. Jordani* the siphonozooids are certainly not so large and prominent as they are in *U. Huxleyi* if one may judge from the figures of that species given by Kölliker (1880 Pl. IX, fig. 37).

Moreover in *Umbellula Huxleyi* the siphonozooids are numerous on the third region of the rachis and there are calcareous corpuscles in the end bulb.

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A feature in which this specimen differs markedly from other species of the genus in the collection is the very slender upper swelling of the stalk. Unfortunately NUTTING does not give the measurements of this part of the type specimen and it is impossible to judge from the very poor photographs that illustrate his paper what its characters are.

It was found at the same station as the third specimen of *U. antarctica* and it might seem more reasonable to regard it as possibly a young specimen of that species than to be related to a specimen from such a distant locality as Hawaii but until we possess more information concerning the development of the species it may be more useful, by calling attention to its special characters, to regard it as distinct.

5. *Umbellula pellucida* Kükenthal. (Pl. IV, figs 25, 26 and Textfig. 29 B & C).

Umbellula pellucida Kükenthal 1902. Zool. Anz. Bd 25, p. 593.
Umbellula pellucida Kükenthal and Broch 1911. "Valdivia" Pennatulacea. p. 300, Pls XVI & XX.

Stat. 300. 10°48′ S., 123°23′ E. Near Rotti. 918 metres. 2 Ex.

Both of these specimens appear to be so much contracted and distorted that it is difficult to determine with any degree of accuracy the true measurements of the autozooids and upper regions of the rachis.

The total lengths of the two specimens are (A) 315 mm. (B) 338 mm.

The autozooids are situated quite at the summit of the rachis and therefore this region can be measured only as the diameter of the autozooids, i. e. from 2—3 mm. in length. The second region of the rachis is 18 or 19 mm. in length, and the third region 252 (A) and 270 (B) mm. in length and about 1 mm. in diameter in its narrowest part. The 3rd region is quadrangular in section.

The stalk is 42 mm. in length and 2 mm. in diameter in A and 45 mm. in length and 2.45 mm. in diameter in B. An important feature of this species is that the basal bulb merges into the upper swelling and is very small.

Autozooids. There are 6 autozooids arranged in a single whorl in A and 9 autozooids in B. of which eight stand in a whorl and one in the centre of the disc. From its relation to the upper termination of the axis the central autozooid is probably the terminal one. It is curious that there is no trace of such an autozooid in A. In both specimens there is evidence of severe contraction in the autozooids. The length of the bodies varies from 8—10 mm. and their diameter from 2.5 to 2.45 mm. The tentacles are very much shrivelled up and in many cases the pinnules are broken off. They are 1—1.5 mm. in length. The stomodaeum is everted in many of the autozooids, showing the severity of the contraction they have undergone.

Siphonozooids. It is impossible to determine accurately the distribution of the siphonozooids as there is evidence that the superficial epithelium has been rubbed off in many places.

In specimen A the siphonozooids appear to be evenly distributed on the second region of the rachis and to extend between the autozooids on to the first region but in specimen B they have been rubbed off (?) those parts of the rachis lying superficially to the anthosteles of the autozooids.

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I have not been able to find any siphonozooids on the 3rd region of the rachis, but a microscopic preparation shows a few small scattered siphonozooids on the upper swelling of the stalk.

No spicules have been discovered in any part of the rachis or stalk.

Colour. The upper swelling of the stalk and the basal bulb are brown, the third region of the rachis straw-coloured. The autozooids are brownish grey and the tentacles a darker shade of brown.

This species approaches in many respects *Umbellula pellucida* of KÜKENTHAL from a depth of 628 metres off the coast of Somaliland.

The points of similarity are the transparency of the outer skin, the length and diameter of the bodies of the autozooids, the shortness of the tentacles, the situation of the autozooids at the summit of the rachis, and the relative length of the stalk and rachis (1 to 6).

It is true that the tentacles of the autozooids are shorter than those of *U. pellucida* but this difference may, perhaps, be accounted for by the extraordinary contraction of the Siboga specimens.

The principal and most important difference between them, however, lies in the number and arrangement of the autozooids.

The longest of the eight specimens of *U. pellucida* obtained by the Valdivia was 225 mm. and in this specimen there were no less than 19 autozooids. In one of the smaller Valdivia specimens, 155 mm. in length, there were 17 autozooids.

The shorter of the two Siboga specimens is 318 mm. in length, i. e. 93 mm. longer than the largest Valdivia specimen and in that there are only six autozooids.

Moreover, in the type specimens of *U. pellucida* the autozooid that is regarded as the terminal autozooid is according to KÜKENTHAL on the dorsal side of the outer circle, in the one specimen of our collection in which such an autozooid can be recognised it is in the centre of the circle.

Family PAVONARIIDAE.

As there are no representatives of this family in the Siboga collection the structure and relationships of the genera included in it will not be discussed at length.

The family may be described as follows: —

Pennatulacea with a long and fleshy rachis with autozooids arranged in rows or rudimentary leaves. Gonads developed in the fully formed autozooids. Radial canals, when present, on the ventral side of the rachis.

A. Without spicules in the autozooids . . . . . *Osteocella.*
B. With spicules in the autozooids . . . . . *Pavonaria.*

The genus *Osteocella* Gray includes *Verrillia* of STEARNS (1873 (3)). The synonyms of *Pavonaria* Kölliker (emend.) are *Balticina* and *Norticina* Gray, *Lygomorpha* and *Göndul* K. & D., *Microptilum* Kölliker, *Stichoptilum* Grieg and *Halipteris* Kölliker.

As the genus *Osteocella* has been ignored or merged with *Pavonaria* by most modern writers a few words are necessary to justify its retention.

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The genus *Osteocella* was founded by GRAY in 1870 and the axis — the only part of the species know to him — further described in two notes in 1872.

The specimens known to GRAY came from Burrard's inlet in British Columbia. MOSS in 1873 gave an excellent description of the soft parts of a specimen of the same species from the same locality and in the same year STEARNS described a specimen of undoubtedly the same species from Barracuda inlet on the same coast. In 1911, I had the opportunity of examining a splendid specimen of the species from Lucy island, British Columbia and was able to confirm the excellence of Moss's description so far as it went.

The British Columbian sea-pen has unfortunately been subjected to many most unfortunate changes of name, the history of which I have described elsewhere (1911 p. 9), and confounded with other species from the coasts of California and elsewhere.

Osteocella differs from *Pavonaria* and *Halipteris* in the entire absence of spicules in the autozooids and rachis and in other characters.

It is therefore very unfortunate that KÜKENTHAL (1913 p. 252), overlooking my paper on the subject, has given *Verrillia Blakei* one of the names given to *Osteocella septentrionalis* as a synonym of *Pavonaria Willemoesi*.

In discussing the characters of *Pavonaria californica* and *P. Willemoesi* from the coast of California, KÜKENTHAL points out that the spicules of these species may be lost if the specimens are preserved either in Formol or in Glycerin. The specimen of *Osteocella* that I received was well preserved in spirit and my series of sections show the histological structure as well as in any material I have examined. There can be no question therefore that the absence of spicules in the rachis of this genus is not due to solution or maceration.

A second suggestion is that the absence of spicules may be a mere local variation but if we accept this view on the evidence that is before us, and regard *Osteocella septentrionalis* as a synonym of *Pavonaria Willemoesi* it will throw the whole system of classification of the Pennatulacea into confusion.

But the absence of spicules is not the only character that separates *Osteocella* from *Pavonaria*. The calices of the autozooids are bound together at the base by fleshy webs so that they form definite leaves. In *Pavonaria*, if I may judge from the descriptions, this fleshy web connecting the calices rarely occurs.

In *Osteocella* there are definite radial canals on the ventral side of the rachis (Textfig. 30 p. 147). KÖLLIKER states definitely (1872 p. 238) that in *Pavonaria* "Radiäre Kanäle fehlen" but states (p. 247) that beautiful radial canals are found in *Halipteris* particularly on the dorsal side of the rachis [1]).

Osteocella septentrionalis attains to the gigantic size of 2 metres in length. It is possible that the young stages of its growth may resemble *Pavonaria* more closely than the adult does, but until these young stages from the coast of British Columbia have been examined *Osteocella* must stand as a distinct genus.

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1) The dorsal side of the rachis of KÖLLIKER is the ventral side of modern authors. The principal radial canals of *Halipteris* are therefore on the same side of the rachis as in *Osteocella* and on the opposite side to those of *Virgularia*.

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Family ANTHOPTILIDAE.

This family was constituted by KÖLLIKER (1880 p. 13) for the species of the genus *Anthoptilum* that were found by the "Challenger" expedition.

He placed it in the Section Spicatae with the Funiculinidae and Stachyptilidae and thus separated it from the Section Pennatuleae.

KÜKENTHAL and BROCH (1911 p. 120) have still further emphasised this separation of Anthoptilidae from the Pennatuleae (Section Pennatulacea penniformia) by including it in their Section Pennatulacea bilateralia.

In my opinion the proper position of the Anthoptilidae is next to the family Pavonariidae and an indication of this view is seen in the system of KÖLLIKER who placed the genus *Halipteris* — a genus now merged with *Pavonaria* — in the same section the "Spicatae". If we examine critically the structure of some of the Pavonariidae, there is very little difference between it and that of the species of *Anthoptilum* that possess leaves.

In *Osteocella septentrionalis* for example the leaves are composed of about twelve autozooids bound together by fleshy webs between their anthosteles (HICKSON 1911 p. 13).

In the description of *Anthoptilum Thomsonii*, KÖLLIKER (1880 p. 13) says that "very often the lowest parts of two, three or more of the polyps are united so as to produce the appearance of very small pinnules, shorter even than those of *Pavonaria finmarchica* but in no place are all the polypes of one row united in such a manner".

From these two quotations it is quite clear that as regards the arrangement of the autozooids in primitive or incomplete leaves there is no essential difference between a representative of the Pavonariidae and some of the Anthoptilidae. The two species referred to in these quotations are moreover alike in the fact that there are no spicules in any part of the autozooids although in most of the Pavonariidae there is a considerable armament of spicules both in the calices and tentacles.

In both *Anthoptilum* and *Pavonaria* (KÖLLIKER 1872) the gonads are found in the fully developed autozooids and not in the region of the immature leaves, as in the Virgulariidae; in both of these genera the rachis is very long as compared with the stalk and the arrangement of the siphonozooids is essentially the same.

It would be interesting to compare the two families as regards the presence or position of the radial canals.

There are radial canals on the ventral side of the axis in *Osteocella* (HICKSON 1911 p. 14) and on the dorsal side of the axis in *Anthoptilum malayense* (p. 145) but this is the only definite information we possess at present. It is true that KÖLLIKER (1872 p. 247) says that in *Halipteris* there are beautiful radial canals which are particularly numerous on the ventral side (i. e. K.'s dorsal side) of the rachis and further that the structure of the rachis of *Pavonaria* (p. 241) is in general ("Im Übrigen"), the same as in *Halipteris* "und vor Allem auf die schöne Ausbildung der Kanäle, die in die 4 Hauptkanäle einmünden", but as in the definition of *Pavonaria* (p. 238) he says definitely that "radiäre Kanäle fehlen", it is impossible to state exactly what the facts of the case are.

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If it is a fact that in *Halipteris* (i. e. *Pavonaria*) *Christii* the radial canals are well developed on the ventral side of the rachis, then this species agrees with *Osteocella septentrionalis* and differs from *Anthoptilum* in this respect. But the whole question offers an interesting field for further investigation.

The main point, however, is that there is very little structural difference between *Anthoptilum* and the Pavonariidae and it is possible that the genus will have to be included in this family.

The Anthoptilidae may be defined as: —

Pennatulacea with a long fleshy rachis, with numerous, large autozooids arranged singly, in oblique rows, in primitive and usually interrupted leaves or in clusters. Siphonozooids numerous, situated between the leaves, extending on to the dorsal track and in some cases also between the autozooids of a row. Gonads formed in the fully developed autozooids. Radial canals on the dorsal side of the rachis. No spicules in the rachis. Calcareous corpuscles sometimes present in the stalk.

There is only one genus *Anthoptilum* with the characters of the family.

Genus **Anthoptilum** Kölliker.

1879. *Virgularia grandiflora* Verrill. Am. J. Sci. Vol. XVII, p. 239.
1880. *Anthoptilum* Kölliker. "Challenger" Pennatulida. p. 13, Pl. IV.
1883. *Anthoptilum* Verrill. "Blake" Expedition. p. 5, Pl. L.
1885. *Benthoptilum* Verrill. Am. J. Sci. XXIX, p. 149.
1885. *Benthoptilum* Verrill. "Albatross" Explorations. p. 510, Pl. II.
1904. *Anthoptilum* Jungersen. Ingolf Expedition. p. 65.
1904. *Anthoptilum* Hickson. Cape Alcyonaria. Pt II, p. 233.
1906 (2). *Thesioides* Thomson and Henderson. "Investigator" Alcyonaria. Pt II, p. 91, Pl. VI.
1909. *Benthoptilum* Stephens. Alcyonaria, Irish Coast. p. 19.
1911. *Anthoptilum* Kükenthal and Broch. "Valdivia" Pennatulacea. p. 232.

In 1879 Verrill described a species of Pennatulacea under the name *Virgularia grandiflora* from the Atlantic coast, and in 1880 Kölliker established the genus *Anthoptilum*. In 1883 Verrill transferred his species to *Anthoptilum* and gave some figures to illustrate its structure.

In 1904 Jungersen gave reasons for believing that Verrill's species is not a *Virgularia* but an *Anthoptilum*.

Kölliker created three species *A. Thomsoni*, *A. Murrayi* and *A. simplex* but did not include Verrill's species in the genus nor make any reference to it.

Jungersen regarded Kölliker's species *A. Thomsoni* and *A. simplex* as varieties of one species and that identical with Verrill's species *Virgularia grandiflora* now *Anthoptilum grandiflorum*. Thomson and Henderson (1906 (2) p. 109) created one new species *A. decipiens* and a new genus *Thesioides* and Miss Stephens (1909 p. 19) described a specimen under the name *Benthoptilum sertum* Verrill from the W. coast of Ireland.

Kükenthal and Broch (1911) examined and described eleven specimens of the genus from the Indian Ocean and after a careful analysis of their characters and those of the species mentioned above came to the conclusion that there is probably only one variable species of the genus to which the name *Anthoptilum grandiflorum* must be applied.

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If we accept KÜKENTHAL's conclusions, the genus presents us with one of the most extraordinary examples of variation within the whole group of the Alcyonaria.

In the collection of the University of Manchester there are two specimens of approximately the same length (800 mm.) one from the Cape of Good Hope and one from the Indian ocean. In the former the rachis bears well defined leaves of 20—25 autozooids, in the latter there are rows of not more than 8 or 9 autozooids separated from one another by considerable intervals. And the two specimens differ in other respects.

If these were the only two specimens known they would certainly be placed by any systematic zoologist in separate species for it is quite incredible that one specimen can be a juvenile form of the other, but if we accept the views of modern authors they are both examples of one species *Anthoptilum grandiflorum*.

Although I am inclined, in the discussion of species in the Alcyonaria, to allow a wide range of variability, it appears to me that in the case of *Anthoptilum* the process of lumping all the specimens into one species has been carried too far and I suggest that it would be convenient to recognise at least three and possibly six species as good.

It is quite clear from the original description of *Virgularia grandiflora* published by VERRILL in 1879 and from the drawing of the same species he gave in 1883 that the autozooids are joined together at their bases to form definite leaves.

JUNGERSEN also in his description of *Anthoptilum grandiflorum* mentions the "wings" (i. e. the leaves).

In the original description of *A. Thomsoni*, KÖLLIKER says "With regard to the position of the polyps, I have further to remark that very often the lowest parts of two, three or more of them are united so as to produce the appearance of very small pinnules, shorter even than those of *Pavonaria finmarchica*, but in no place are all the polyps of one row united in such a manner".

A careful examination of one of the type specimens of this species in the British Museum shows that in some of the rows of autozooids there is really a continuous ridge free from siphonozooids extending from one end of the row to the other. The arrangement is similar to that shown in the figures given by VERRILL (1883) and myself (1904) namely, a group of three or four autozooids are connected at their bases for a distance of two or three millimetres, then there is a gap where the connexion is reduced to a ridge of half a millimetre than another group of two or three united, another gap and so on.

There is undoubtedly a wide range of variation in the character of these leaves both in the specimens from the Cape and in those from Buenos Ayres. On some leaves there are no siphonozooids at all, on others little groups of siphonozooids spread on to the leaf in places where there is a gap between the groups of autozooids and in one specimen I have found a few cases in which they are found actually between the autozooids of a row.

KÖLLIKER states that in his specimens from Buenos Ayres (*A. Thomsonii*) "little groups of zooids, in many places, reach as far as the base of the polyps themselves and are also found between the individuals of one row".

In 1904 (p. 235) I wrote "I have found no siphonozooids between the individuals of the

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rows of autozooids". A renewed examination of the specimens from both localities leads me now to say that siphonozooids may occur between the individuals of a leaf but in all cases they are rarely found in that position.

These rare cases are, however, not sufficient to throw reasonable doubt on the statement that there are definite leaves in *A. Thomsonii* as in *A. grandiflorum*, and that the two species are undoubtedly identical as maintained by JUNGERSEN and by KÜKENTHAL and BROCH.

From the original description and figures of *Anthoptilum Murrayi* however it is quite clear that there are no true leaves; the autozooids are situated in an oblique row on the rachis, some distance apart from one another, and the siphonozooids intrude between the autozooids of a row. Moreover in the description given by JUNGERSEN of specimens attributed to this species no mention is made of the "wings". *Anthoptilum Murrayi*, therefore, differs from *A. grandiflorum* in the fact that the autozooids are not united at their bases to form primitive leavess.

The new species described in this memoir as *A. malayense* agrees with *A. grandiflorum* in the possession of true leaves but differs from it in the size of the autozooids and in the arrangement of the siphonozooids.

The three good species of the genus therefore are: —

Anthoptilum grandiflorum Verrill.
Anthoptilum malayense Hickson.
Anthoptilum Murrayi Kölliker.

Passing on to the more uncertain species.

The genus *Benthoptilum* was suggested by VERRILL in 1885 for a sea-pen that differs from *Anthoptilum grandiflorum* in having enormously long autozozooids. Although the type specimen was only 300 mm. in length the autozooids were no less than 58 mm. in length. Another specimen attributed to the same species was described by Miss STEPHENS in 1909. It was 365 mm. in total length with autozooids of 30 mm.

Benthoptilum sertum resembles *Anthoptilum* in all essential characters and as it seems from the figures and descriptions to have definite leaves it is probably related to *A. grandiflorum*. The only two specimens known at present are very short as compared with the gigantic lengths to which *A. grandiflorum* attains but nevertheless the leaves are composed of numerous autozooids of great size.

On these grounds it seems desirable to keep *Anthoptilum sertum* apart as a distinct species.

Anthoptilum decipiens from the Indian Ocean (THOMSON and HENDERSON 1906 (2) p. 109) has "distinct though rudimentary" leaves composed of three to eight autozooids. It seems to be related to *Anthoptilum grandiflorum* but differs from it in having only a few autozooids to each leaf for a specimen of its size (720 mm.). As there is no figure of the species and only one specimen is known, it may be regarded as a doubtful species.

In 1911 KÜKENTHAL and BROCH (p. 233) described eleven specimens from the Indian Ocean under the name *A. grandiflorum* and their description is illustrated by six excellent figures.

In none of these specimens, so far as can be judged by the text and illustrations, are the autozooids joined to form continuous leaves in the manner shown in the typical specimens

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of *Anthoptilum grandiflorum*. The descriptions, however, given by these authors of the arrangement of the autozooids is ambiguous.

In their diagnosis of the family Anthoptilidae (1911 p. 232) appears the following passage. "Bilateral gebaute Seefedern mit lateral angeordneten schrägen Reihen von einzelstehenden Polypen, die in schräg gestellte Gruppen zusammentreten können". In the description of the species they write "Die Polypen stehen am Kiel in schräg von dorsal unten nach ventral oben verlaufenden Reihen, die im oberen Teile meist durch eine bündelförmige Anordnung ersetzt werden, und sind entweder gleich gross oder werden am unteren Ende des Polypars auf eine kürzere oder längere Strecke kleiner. Häufig sind sie an der Basis ein Stück weit miteinander verschmolzen".

If it is meant by this last sentence that all the autozooids are joined together (verschmolzen) then the statement in the description of the family that the autozooids are isolated (einzelstehend) is not correct.

The description of the individual specimens however and the figures make it quite clear that in these Indian Ocean forms collected by the "Valdivia" continuous leaves of autozooids are not formed such as we find in *A. grandiflorum*.

There is in our collection a specimen of *Anthoptilum* obtained by Prof. Stanley Gardiner off Saya de Malha in the Indian Ocean 228 metres. It is 860 mm. in length and is similar in general characters to specimen VII, (560 mm. in length) of the "Valdivia" collection. When this specimen is compared with specimens of the same length of *Anthoptilum grandiflorum* from the Cape there can be no hesitation in regarding them as distinct species.

The important question to be answered is whether in the "Valdivia" collection there is such a gradation between the *A. Murrayi* form and the *A. grandiflorum* form to justify the fusion of the two species. Kükenthal and Broch (1911 p. 238) say that there is such a gradation but there is only one of the series (N^0 1) in which it is stated that the autozooids are fused together, "Mitunter sind die Polypen an ihrer Basis ein Stück weit verwachsen" (p. 235) and in that specimen the siphonozooids are situated between the autozooids, a position in which I have very seldom found them in any specimen of *A. grandiflorum*.

But even if there were some gradation between the extreme forms collected by the "Valdivia" and the typical forms of *A. grandiflorum* on the one hand and *A. Murrayi* on the other it would nevertheless be inconvenient and unscientific to lump the two species together.

I have examined a large number of specimens of various sizes of *A. grandiflorum* from the Cape and have found that they are quite distinct from any of the specimens collected by the "Valdivia".

Jungersen has examined several specimens of *A. grandiflorum* form the N. Atlantic and has found good reason for separating them from *A. Murrayi*. It seems therefore only reasonable to keep these three groups apart until a better proof of their identity is forthcoming.

Our knowledge of the anatomy of *Anthoptilum* is still very scanty, we know very little about the canal system, the structure of the autozooids or the axis. A further study of these structures in specimens from different parts of the world may yield new characters to distinguish the species.

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In the meantime I would suggest that the specimens collected by the "Valdivia" expedition together with the *Anthoptilum Murrayi* of THOMSON and HENDERSON be separated from the others as a distinct species to be named *Anthoptilum Kükenthali.*

Whether the *Thesioides inermis* of THOMSON and HENDERSON also from the Indian Ocean should be included in the same species or not I will not discuss. KÜKENTHAL and BROCH consider that it is a variant of the same species but in any case it seems clear that it is an *Anthoptilum* and not the type of a distinct genus.

The three doubtful species therefore are: —

Anthoptilum sertum Verrill,
Anthoptilum decipiens T. and H.,
Anthoptilum Kükenthali Hickson,

and to these might be added a fourth

Anthoptilum inermis T. and H.

The position of *Anthoptilum simplex* (Köll.) must remain doubtful. It was found off Tristan d'Acunha and seems to be related either to *A. Murrayi* or *A. Kükenthali* and is probably a young form as suggested by JUNGERSEN (1904 p. 67).

These species may be arranged in two groups: —

A. Autozooids united at their bases to form leaves.

1. Anthoptilum grandiflorum Verrill.
   Virgularia grandiflora Verrill
   Anthoptilum Thomsoni Kölliker
   Anthoptilum grandiflorum Jungersen
   Anthoptilum grandiflorum Hickson.
   Distribution: N. Atlantic 1064—1342 metres.
2. Anthoptilum malayense n. sp.
   Distribution: Malay Archipelago 959 metres.
3. Anthoptilum sertum Verrill
   Benthoptilum sertum Verrill
   Benthoptilum sertum Stephens.
   Distribution: N. Atlantic 1270—1962 metres.
4. Anthoptilum decipiens Thomson and Henderson.
   Distribution: Indian Ocean 925 metres.

B. Without leaves. The siphonozooids interpose between the autozooids of a row.

5. Anthoptilum Murrayi Jungersen.
   Distribution: North Atlantic 1545—2286 metres.
6. Anthoptilum Kükenthali Hickson
   ex parte *Anthoptilum grandiflorum* Kükenthal and Broch
   Anthoptilum Murrayi Thomson and Henderson.
   Distribution: Indian Ocean 748—3548 metres.

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7. Anthoptilum inermis Thomson and Henderson

Thesioides inermis Thomson and Henderson.

Distribution: Indian Ocean 846 metres.

8. Anthoptilum simplex Kölliker.

Distribution: W. of Tristan d'Acunha 2743 metres.

In addition to the specimens enumerated above from the Atlantic and Indian Oceans NUTTING records a number of specimens belonging to the genus from the Pacific Ocean.

Anthoptilum grandiflorum from the coast of California 914 metres (1909 p. 710), *A. Murrayi* from Hawaii 426 metres and off the coast of California (1908 p. 561) and *A. Murrayi* off the coast of Japan 1097—2225 metres (1912 p. 48). The specimens are not very fully described and it is difficult to say without more detailed information whether the specimens described under the name *A. Murrayi* are more closely related to the Atlantic forms of this species or to the forms included in the species *A. Kükenthali.*

1. *Anthoptilum malayense* n. sp. (Pl. VII, figs 42 & 43).

Stat. 52. 9° 3′ S., 119° 56′ E. Off Flores island. 959 metres. 2 Ex.

Both specimens show the characteristic S-shaped bend in the rachis.

The larger specimen has a total length of 635 mm. of which 118 mm. may be attributed to the stalk. The rachis has a width at the 8th leaf from the proximal end of 5.5 mm. and its dorso-ventral diameter is 10 mm. and maintains these dimensions approximately to a short distance from the distal extremity. At this extremity the rachis is conical, the leaves small and the axis does not protrude.

On the sides of the rachis there are numerous alternate oblique rows of autozooids overlapping one another on the ventral side but leaving a well defined bare track 4 mm. in width on the dorsal side. As the bases of the autozooids are united, these oblique rows will be called the leaves.

In the proximal leaves there are only a few autozooids arranged in a single row and the leaves are from 20—25 mm. apart, but passing upwards the number of autozooids rapidly increase and the leaves are closer together. New autozooids are added both above and below so that each leaf consists of three or more rows of autozooids and at the distal end of the rachis the leaves become so crowded together that the whole surface with the exception of the dorsal track seems to be a dense cluster of autozooids.

At the proximal end of the rachis the leaves are represented by a row of 2 or 3 small autozooids, united together to form a primitive leaf, the young autozooids being on the ventral side of each leaf.

At the 8th leaf from this end the number has increased to 20, at the 21st leaf on the right side there are 34, and towards the distal end the number becomes so great that it is impossible to count them without injuring the specimen. In the middle region of the rachis where the average length of the autozooids is about 8 mm. they are fused together at their bases for a distance of 5 mm. continuously from one end of the leaf to the other.

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Autozooids. There is considerable variation in the size of the autozooids, as new young ones seem to be constantly added to the original single row, but the larger ones have a body length of about 9 mm. and a diameter of 2.5 mm. and the tentacles are about 3.5 mm. in length.

Each autozooid consists of a body or calyx which is rigid and not retractile and an anthocodia bearing the crown of tentacles which has thin walls and capable of a certain amount of retraction; but the anthocodiae never seem to be withdrawn into the thickened basal part. The anthocodiae are very liable to be broken off and the autozooids to be represented there by the calyx only.

The siphonozooids are very small and very numerous. They are crowded in immense numbers between the leaves and extend on to the dorsal track.

When the dorsal track is examined with a lens the following remarkable arrangement will be seen (Plate VII, fig. 42). In the middle line there is a track 3.5 mm. in width quite free from siphonozooids. On both sides of this there is a track with siphonozooids which is interrupted opposite each alternate leaf by a space free from them. This arrangement is constant throughout the whole length of the rachis in this specimen and in the smaller one as well. In a few rare cases, siphonozooids have been found mounted on the bases of the leaves but they are never found between the autozooids of the same leaf. All the siphonozooids seem to possess two dorsal mesenteric filaments.

The stalk is 118 mm. in length. Above, it is continuous with the rachis but at a distance of 20 mm. from its commencement it is enlarged to a swelling with a maximum diameter of 14 mm. then it narrows again to a diameter of 10 mm. and ends below in a bluntly conical bulb.

The surface of the swelling and the greater part of the stalk is scored by irregular deep longitudinal grooves — probably due to shrinkage — but the bulb is almost smooth.

Spicules. A few small oval spicules of which the largest are about .01 × .015 mm. are found in the muscular walls at the base of the stalk. In the upper part of the stalk none were found.

Male gonads were found at the base of the autozooids of the distal and middle regions of the rachis but they were not ripe.

The smaller specimen is 400 mm. in length of which about 73 mm. may be attributed to the stalk. In all the general characters that have been examined it resembles the larger specimen.

This species belongs to the group of species which include *A. grandiflorum*, *A. sertum* and *A. decipiens* characterised by the fusion of the autozooids to form definite but imperfect leaves.

As in the other species the leaf formation is not uniform and exhibits wide variation. In the lower part of the rachis where each leaf consists of single row of autozooids we may find 3 or 4 autozooids with their bases united for a distance of 2.5 mm. from the surface, then a gap in which the leaf is reduced to a ridge 0.5 mm. in height, then another gap and so on; but in no case do the siphonozooids extend between the autozooids of a leaf.

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When compared with specimens of *Anthoptilum grandiflorum* from the Cape of Good Hope the most obvious difference is the small size of the autozooids.

The largest autozooids are not more than 9 mm. in body-length whereas in the Cape specimens of a similar size they are 15 or 16 mm. in length.

The specimens of *Anthoptilum grandiflorum* and *A. Thomsonii* obtained from Buenos Ayres also had larger autozooids but in some of the specimens from the N. Atlantic the autozooids seem to be smaller than in *A. malayense.*

The tentacles also are very much smaller than in the S. Atlantic forms of *A. grandiflorum.*

In the only two specimens of *A. sertum*, both much shorter than the Cape and Malay specimens, the autozooids are very much longer.

Another distinguishing feature of the species is the greater number of autozooids in each leaf. If we take a leaf near the middle of the rachis about 35 autozooids can be counted. In the largest specimen of the Cape specimens of *A. grandiflorum* there are not more than 25 in the same region and about the same number in the specimens from Buenos Ayres. In the North Atlantic forms the number is much less.

In none of the other species has the regular alternate break in the siphonozooids of the dorsal track been described. In the specimens of *A. grandiflorum* from Buenos Ayres similar breaks have been figured by KÖLLIKER (1880) but they are not regularly alternate as I have confirmed by inspection of the type specimens. In the Cape specimens of *A. grandiflorum* there are no breaks in the continuity of the dorso-lateral tracks of siphonozooids.

The species may be defined as follows: —

Colony thick and fleshy with the usual S-shaped bends in the rachis. Rachis about five and half times the length of the stalk. Autozooids united at their bases to form definite leaves. Numerous autozooids (35 or more) in each fully developed leaf. Autozooids short (i. e. about 9 mm. or less). Siphonozooids very numerous between the leaves and extending on to the dorsal track leaving a gap free from siphonozooids opposite each alternate leaf. A median strip of the dorsal track about 2—4 mm. wide extending from one end of the rachis to the other is free from siphonozooids. Spicules oval in shape, .015 mm. in length are found in the base of the stalk only.

KÜKENTHAL and BROCH (1911 p. 165) have pointed out that in many Alcyonaria the deep-sea forms have larger and fewer autozooids than the more shallow-water forms. As the important differences between *A. malayense* and *A. grandiflorum* (Cape specimens) are in respect of the size and number of the autozooids, it may be remarked that *A. malayense* with smaller and more numerous autozooids came from deeper water (959 metres) than *A. grandiflorum* (237 metres).

Notes on structure. A series of vertical sections of the dorsal track of *Anthoptilum grandiflorum* shows the following structures (Plate VIII, fig. 58).

Superficially there is the usual form of columnar epithelium with scattered unicellular glands. Below this there is a rather thick and apparently tough supporting layer of mesogloea. Below this again there is a thick layer of longitudinal muscular fibres (*M.*) and below this a layer of short curved canals (*R. c.*) lined by a columnar (ciliated?) epithelium which communicate with the main dorsal longitudinal canal (*D. l. c.*).

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There are no siphonozooids in the median strip of the dorsal track.

The canals clearly correspond in position and structure with the radial canals of *Virgularia* but they are not so long in proportion, the superjacent layer of muscles is not represented at all in *Virgularia* (cf. Plate VIII, fig. 59).

Egss or sperm sacs are found in the body cavities of the autozooids of the middle region of the rachis. At the distal end the autozooids do not seem to bear them.

According to Miss STEPHENS (1909) on the authority of THOMSON, *Anthoptilum sertum* is viviparous. This, however, has not been proved to be a fact. Miss STEPHENS kindly sent to me some autozooids of the Irish specimen and I found that the gonads were undoubtedly sperm sacs and the specimen a male.

In 1909 Mrs MUSGRAVE described numerous siphonozooids, situated just below the maximum swelling of the stalk in a specimen of *Anthoptilum* from the Indian Ocean. As KÜKENTHAL and BROCH (1911 p. 525) have expressed a doubt as to whether these structures are really siphonozooids I have re-examined the specimen and the sections that she made. There is, of course, no doubt whatever that Mrs MUSGRAVE was perfectly correct. The siphonozooids are, it is true, very small (total diam. 0.2 mm., diam. of stomodaeum 0.1 mm.) but they show the stomodaeum with a typical siphonoglyph and eight mesenteries. They differ from the other siphonozooids in having no dorsal mesenteric filaments.

The specimen was not, however, an *Anthoptilum grandiflorum* according to the system given above but *Anthoptilum Kükenthali*. It was obtained by Prof. GARDINER off Saya de Malha in the Indian Ocean 228 metres and belongs to the same group as those described in the "Valdivia" report.

It is a curious fact that I have not found either the siphonozooids or the papillae on which they are situated in any other specimen nor in any other species although I have made several stained preparations of the same region of the stalk.

Family VIRGULARIIDAE.

The family Virgularieae of KÖLLIKER (1872) included *Virgularia*, *Stylatula*, *Pavonaria*, *Scytalium*, *Acanthoptilum*, *Funiculina* and *Halipteris*. Since that date, by common consent, *Funiculina* has been separated into a family of its own; and at the suggestion of JUNGERSEN (1904), supported by BALSS (1910) and by KÜKENTHAL and BROCH, *Halipteris* is merged with *Pavonaria*. JUNGERSEN and BALSS agreed in separating *Pavonaria* from the Virgulariidae and constituting for it a new family Pavonaridae (JUNGERSEN) or Balticinidae (BALSS) and they also included the genera *Scytalium* and *Acanthoptilum* in this family.

KÜKENTHAL and BROCH (1911) expressing disapproval of the separation of the family Pavonaridae of JUNGERSEN, retained all KÖLLIKER's genera with the exception of *Funiculina* in their family Virgulariidae dividing it into two sub-families of which the first — the Pavonariinae — contained *Pavonaria* alone and the second — the Virgulariinae — all the others.

The system adopted in this memoir resembles more closely that of JUNGERSEN and BALSS

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but differs from it in the transference of *Acanthoptilum* and *Scytalium* to the family Pennatulidae. The Virgulariidae includes only two genera (*Virgularia* and *Stylatula*), the Pavonariidae also only two genera (*Osteocella* and *Pavonaria*).

The disadvantage of uniting all these genera into one family according to the system of KÖLLIKER is that it renders the characters of the family very vague and indefinite.

KÖLLIKER's definition (1872 p. 182) of the family was: —

"Pennatuleen mit langem, schmalem Polypenträger, kleinen Blättern oder unmittelbar am Kiele sitzenden Polypen" and if we turn to the scheme of KÜKENTHAL and BROCH (1911 p. 155) we find that the Virgulariidae are said to have a "Kiel dünn und langgestreckt" in contrast to the Pennatulidae and Pteroeididae in which the "Kiel" is "dick".

A long narrow rachis is by no means a good definitive character to distinguish any one family of Pennatulids, even when it is combined with the character of possessing leaves. According to either of these schemes some specimens of *Anthoptilum* and of *Pennatula Murrayi* would certainly be included in the family and forms like *Osteocella septentrionalis* or *Virgularia Gustaviana* with their thick fleshy rachis would be excluded.

On the other hand the two genera *Virgularia* and *Stylatula* show one character and possibly two which certainly distinguish them from the Pavonariidae. These characters are (1.) the formation of the gonads in the immature leaves and (2.) the presence of dorsal radial canals.

As regards the first of these characters, it may be said with some confidence that in all the other genera of Pennatulacea the ova or sperm sacs are always found, in adult forms that have not just spawned, attached to the mesenteries of the fully formed autozooids. In these two genera on the other hand, although ripe eggs may be found in other parts of the rachis, the eggs and sperm sacs, attached by their capsule stalks, are only found in the region of the immature leaves (Pl. VIII, fig. 60).

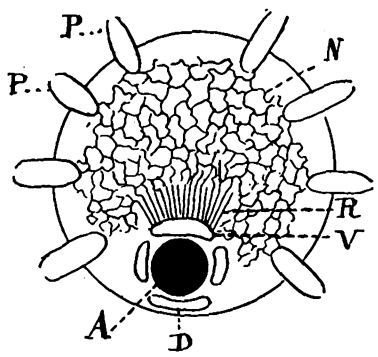

Fig. 30. *Osteocella.*
Transverse section through rachis of *Osteocella* to show the radial canals *R* on the ventral side. *A.* axis. *D.* dorsal longitudinal canal. *N.* network of Solenia. *P.* leaves. *V.* ventral longitudinal canal.

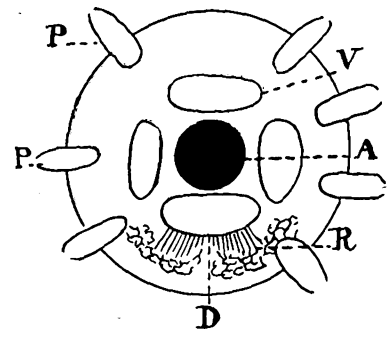

Fig. 31. *Virgularia.*
Transverse section through rachis of *Virgularia* showing radial canals (*R*) on the dorsal side. Lettering as fig. 30.

As regards the radial canals, it is possible that structures homologous with these organs may be found in other Pennatulids, such as the ciliated brown tubes of *Pennatula Murrayi* and the ventral radial canals of *Osteocella*, but there are no other genera except *Anthoptilum* in which they occur in the definite place and relationship that we find them in *Virgularia*. Our knowledge of these canals in *Stylatula* is not so complete, but from the definite statement of KÖLLIKER (1872 p. 216) that radial canals occur in the genus, and from the statement and figures of KOREN and DANIELSSEN (1877 Pl. X, fig. 11) that they occur on both dorsal and ventral sides of *Dübenia* (i. e. *Stylatula*) *abyssicola* there can be little doubt that they occur on the dorsal side in *Stylatula*.

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There is a great deal of variation in the family as regards to the formation of the leaves. In some of the species such as *Virgularia Gustaviana* and *Stylatula gracilis* the autozooids are united together for a considerable part of their length above the rachis forming thereby leaves as perfectly developed as in the Pennatulidae. In other species, on the other hand such as *Virgularia gracillima, V. rubra* (Plate VII, fig. 47) and *Stylatula elegans* the autozooids are united only at the base and the leaves may be said to be imperfectly developed.

The family Virgulariidae may be described as follows: —

Pennatulacea with a long and usually slender rachis, with autozooids arranged in perfectly or imperfectly developed leaves, with a long series of immature rows of leaves at the proximal end of the rachis. Gonads developed only in the young autozooids of the immature leaves. Radial canals present on the dorsal side of the rachis.

A. Without spicules in the leaves . . . . . *Virgularia.*
B. With spicules in the leaves . . . . . *Stylatula.*

Virgularia appears to be cosmopolitan and although usually found in comparatively shallow water does extend downwards to depths of 1000 metres.

Stylatula on the other hand appears to be confined to the Atlantic Ocean including the Mediterranean Sea, and to the coasts of California. It is also usually found in shallow water but specimens have been obtained at depths of 720 metres off the coast of Norway (GRIEG 1892 p. 12) and 811 metres off the E. coast of N. America (VERRILL 1885 p. 150).

Genus **Virgularia** Lamarck.

Virgularia Lamarck. 1816. Hist. Nat. anim. sans Vertèbres. 1e édit., Tom, II, p. 429.
Virgularia + *Halisceptrum* Kölliker. 1872. Die Pennatuliden. pp. 182 and 147.
Virgularia + *Cladiscus* Kor. & Dan. 1877. Fauna Litt. Norveg. pp. 90, 100.
Svava Kor. & Dan. 1884. Norske Nordhavns Exp. p. 4.
Deutocaulon Marshall & Fowler. 1887. "Porcupine" Pennatulida. p. 461.
Scytaliopsis Gravier. 1908. Tadjourah Alcyonaires. p. 236.
Svavopsis Roule. 1908. Alcyon. d'Amboine. p. 181.
Virgularia Kükenthal & Broch. 1911. "Valdivia" Pennatulacea. p. 323.
? *Stephanoptilum* Roule. 1905. "Talisman" Pennatulids. p. 454.

The earliest record we possess of a specimen of the genus *Virgularia* is the description of the two kinds of the "Sagitta marina" found in the Malay Archipelago by RUMPHIUS published in the year 1705. MÜLLER's description of the European sea-pen now known as *Virgularia mirabilis* was not published until the year 1776.

PALLAS in 1776 described three species of these Pennatulids under the generic name Pennatula; namely the two kinds of Sagitta marina of RUMPHIUS (*Pennatula iuncea* and *P. grandis*) and the *Pennatula mirabilis* of MÜLLER.

LAMARCK in 1816 proposed the generic name *Virgularia* and included in his genus the *Pennatula juncea* and *Pennatula mirabilis* of PALLAS together with a new species which was called *Virgularia australis.*

The definition of the genus given by LAMARCK is of little more than historic interest. He and the writers of his time knew very little about the structural features of the organisms

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they described and, although we may admire their insight in recognising the generic distinction of these species, their diagnoses are at the present day of little value.

The first important contribution to our knowledge of the structure of *Virgularia* is that of KÖLLIKER (1872) in which certain anatomical features are described which place the genus on a firm foundation. Many of KÖLLIKER's anatomical observations were confirmed in the valuable memoirs by the MARSHALLS (1882), by JUNGERSEN (1904) and by KÜKENTHAL and BROCH (1911).

The principal points in KÖLLIKER's definition of the genus are 1^0 the absence of spicules in the leaves and rachis, 2^0 the presence of radial canals on the dorsal side of the rachis, 3^0 the presence of sexual organs only in the region of the undeveloped leaves (except in one species *V. glacialis*). These three characters combined are still the most important characters for distinguishing the genus from others that might seem on superficial examination to be closely related to it.

There is one point in KÖLLIKER's definition that needs amendment and that is his reference to the lateral rows of siphonozooids (laterale Zooidstreifen).

In the general description of the genus (1872 p. 183) he divides the rachis into three regions; the distal region of the fully developed leaves, the middle region of the undeveloped leaves and the proximal region "mit einem lateralen Zooidstreifen" continuous with the stalk.

The zooids in this proximal region are as a matter of fact not siphonozooids but undeveloped autozooids. It is true that both JUNGERSEN and KÜKENTHAL describe these zooids as siphonozooids (i. e. zooids or "zooiden") and it is necessary therefore to state the reasons which have led me to dispute the accuracy of the statement.

In the first place the MARSHALLS (1882 p. 71) made a very careful microscopical examination of this region in *Virgularia mirabilis*, the species in which the bulk of the anatomical work of other writers has been done, and give no account of the presence of this lateral row of siphonozooids. They state that "at the lower end of the rachis not only do the leaves get smaller but their component polyps get more and more imperfect and at last become reduced to mere pit-like depressions of the surface". It is clear therefore that they considered the "zooidstreifen" to be composed of autozooids. But the MARSHALLS did not prove their point, because a "row of pit-like depressions" of the surface might be either a row of young autozooids or a row of young siphonozooids, and to determine the probable fate of these zooids some further observations were necessary.

In the upper part of the second or middle region of the rachis the leaves are composed of incompletely developed autozooids approximately equal in number to the autozooids of the distal regions and between the leaves there is a horizontal row of siphonozooids. In the lower part of this middle region the autozooids of the leaves are still less developed and the rows of siphonozooids have disappeared. In the proximal region (the "zooidstreifen") the leaves are represented by a continuously diminishing number of "pit-like depressions" and there are no siphonozooids between them. The continuity of the "zooids" of this region with the succession of leaves and not with the succession of rows of siphonozooids is perfectly certain.

According to JUNGERSEN however "these zooids are never developed to polyps but keep the zooid form", a statement which was based on the examination of young (22 mm.) specimens.

It is impossible to say what becomes of these zooids without more detailed knowledge than we possess of the process of growth in *Virgularia* but there is one character these zooids

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possess, apart from their continuity with the leaves of the middle region, which suggests very strongly that JUNGERSEN's conclusion is erroneous.

It is, I believe, a general rule in the Order Pennatulacea that the gonads are borne by the autozooids and that the siphonozooids are barren. This is certainly the case in the middle region of the rachis of *Virgularia*.

The zooids of the proximal region do bear young gonads (Plate VIII, fig. 60) and therefore they are more correctly regarded as young autozooids than as young siphonozooids. It is a matter of considerable difficulty with these Pennatulids to determine with certainty, by surface examination with a lens, the difference between siphonozooids and young autozooids and it is quite impossible to determine by this means whether siphonozooids are or are not present in any particular region of the rachis or stalk. In microscopic sections of the upper regions of the rachis the siphonozooids can be distinguished from the autozooids by the short stomodaeum provided with a pronounced siphonoglyph, by the absence of mesenteric filaments and by the absence of gonads.

In the proximal region, where the zooids are obviously in a very imperfect state of development, the first two of these characters are not to be relied upon. The pit-like depressions might assume either the characters of the stomodaeum of an autozooid or the characters of the stomodaeum of a siphonozooid, the mesenteric filaments might or might not develope later. But the presence of young gonads seems to prove almost conclusively that they are destined to become autozooids and not siphonozooids and that in consequence the correct interpretation of the "zooidstreifen" is that they represent rudimentary leaves.

The conclusions arrived at were the result of the examination of several series of sections of the region concerned taken from specimens of *Virgularia Rumphii* and *V. juncea* and confirmed by a single observation of *V. gracillima*.

There is yet another point in which some authors appear to have been mistaken. The MARSHALLS state that the autozooids "appear simultaneously, the youngest leaves having the same number of polypes as the oldest or more mature leaves". This statement is certainly not true for the three species of *Virgularia* I have investigated. In the lowest part of the rachis the pit-like depressions which give rise to the young leaves are formed in succession from the dorsal to the ventral side of the rachis. The autozooid situated at the ventral edge of the leaf is therefore the youngest as in other Pennatulids (Plate VIII, fig. 60 *A* 5). It is true that in passing upwards from the base of the rachis the number increases with astonishing rapidity so that leaves which look like simple ridges on the sides of the rachis appear to have the full complement of autozooids.

But, after all, the difference between *Virgularia* and other genera is only a difference of degree and not one of fundamental importance. In this respect I am in agreement with JUNGERSEN (1904 p. 25) who correctly criticises the MARSHALLS' statement that all the autozooids appear simultaneously.

The radial canals. This system of canals was first described by KÖLLIKER in the species *Virgularia (Halisceptrum) Gustaviana*, and subsequently by the MARSHALLS in *Virgularia mirabilis*.

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As they seem to be a characteristic feature of the genus further observations on their structure and distribution are greatly needed.

They are situated between the epithelium of the dorsal track and the main dorsal canal and their general course is parallel with a line running from the centre of the axis to the middle of dorsal surface.

A vertical section (Pl. VIII, fig. 59) through this region of *Virgularia Rumphii* shows externally a columnar epithelium (*Ep.*) bearing many goblet mucus cells and below this a network of irregular endoderm canals lying in the mesogloea — the solenia or "nutritive canals" (*So*) of KÖLLIKER — lined internally by endoderm cells of irregular form bearing a number of zoochlorellae (*Z*). These nutritive canals or solenia communicate below with the system of radial canals (*R.c.*), and the radial canals communicate with the main dorsal canal by narrowed passages lined with a modified epithelium (Textfig. 32). The relation of these parts were correctly described by KÖLLIKER and by the MARSHALLS.

The character of the epithelium lining these canals is clearly specialised as, with many of the ordinary histological reagents, it stains much more deeply than the surrounding tissues. It is composed of numerous small cylindrical cells with a clear border and deeply staining nuclei. The MARSHALLS say that this epithelium has a very glandular appearance and suggest that the canals may be excretory in function, but this statement is not in agreement with my own observations on *Virgularia Rumphii*, *V. juncea* and *V. mirabilis* in which I have failed to find any trace of excretory or other granules. I believe that the epithelium is ciliated and that the function of the radial canals is neither excretory nor nutritive. The reasons for this opinion are that the cell structure is similar to that of a columnar ciliated epithelium such as that of the siphonoglyph of the siphonozooids; in the lumen of the canals numerous twisted fibrillae (Pl. VIII, fig. 59. *Rc'*)

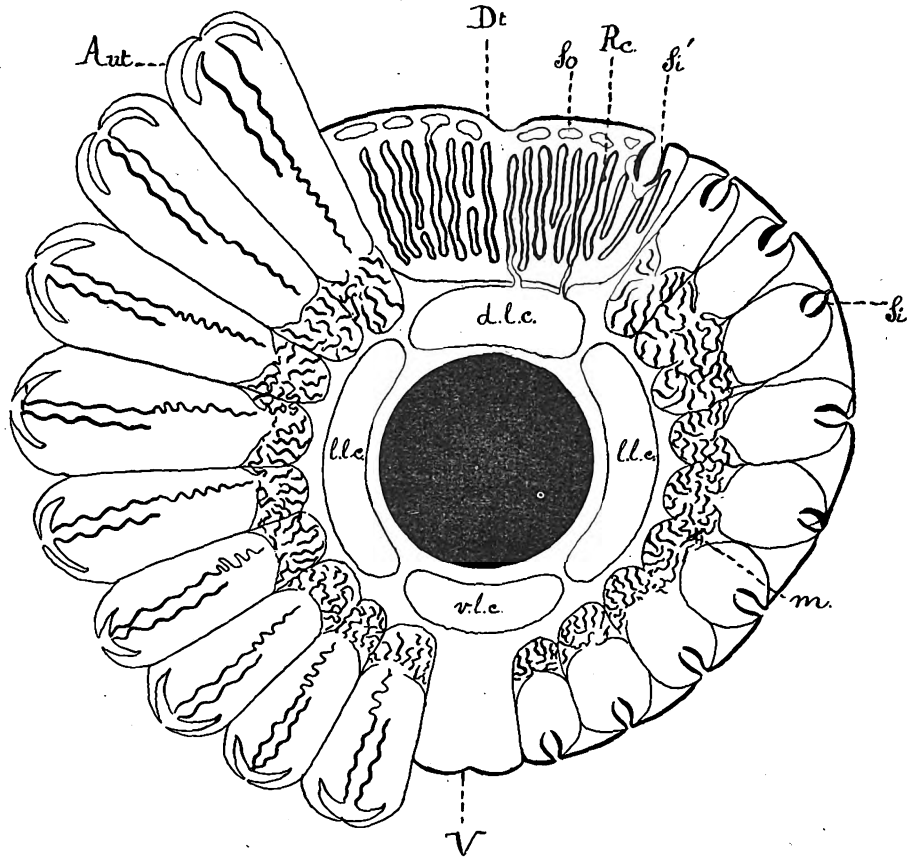

Fig. 32. Diagram of a transverse section of a *Virgularia*.

On the right, the section is supposed to pass through a row of siphonozooids, on the left through a leaf of autozoöids. In the centre is seen the axis surrounded by the four main longitudinal cavities, the dorsal cavity *d. l. c.*, the ventral cavity *v. l. c.* and the two lateral cavities *l. l. c.*

On the dorsal side there is seen a section through the dorsal track (*Dt*) with its branching nutritive Solenia (*So*) communicating with the system of Radial canals (*Rc*). At *Si'* a single siphonozooid is seen on the dorsal track communicating with the Solenia.

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are always found which are probably the broken off cilia and in some cases these cilia are attached to the free border of the epithelium; the radial canals occupy a similar position to the short tubes described in *Pennatula Murrayi* which are undoubtedly ciliated (cf. page 159 *Scytaliopsis*).

If these canals were nutritive in the sense of being digestive in function, if they were excretory in function or if they were phosphorescent organs the cytoplasm of the free borders of the cells would, in some cases at least, be granular but they are always clear. Therefore it seems very unlikely that they perform any one of these three functions. If not, what function do they perform? Now, it is well known that many Pennatulids have considerable powers of distension and contraction of the tissues and the distention must be due to a rapid suction of water into the general canal system and particularly into the main canals. If the radial canals are lined with a ciliated epithelium they would provide the type of organ for regulating the flow of water we might expect in these fleshy forms. The actual proof that they are ciliated is, however still wanting.

In her valuable paper on the physiology of the Pennatulids, Mrs MUSGRAVE (1909) suggests that the radial canals in *Virgularia* may open directly to the exterior as, according to GRAVIER, (1908) they do in *Scytaliopsis*. They do not. Their only communication with the exterior is by way of the superficial solenia and the siphonozooids of the dorsal track.

The siphonozooids of the dorsal track in the two species I have investigated are few in number, have a relatively long stomodaeum and open directly into the superficial system of solenia. They are, in most cases, very difficult to see on surface examination but they seem to have no relation to the siphonozooids which occur in rows between the leaves. In *V. Gustaviana* a remarkably fleshy species the siphonozooids are very numerous, in the more slender species they are rare.

The stalk. It is not an easy matter to determine with accuracy the exact length of the stalk because in some cases the lowermost rows of undeveloped leaves are sunk into a groove so that the boundary line between rachis and stalk is hidden and also because in most of the preserved specimens the terminal position of the stalk has shrunk away from the axis.

The method adopted in this memoir for obtaining a measurement of the stalk was to take the length from the last visible undeveloped leaf as seen with a magnifying glass to the extreme proximal end of the axis when straightened out from the bent position it usually assumes. If we use this measurement we find there is a difference in the relative length of stalk to rachis between some species. Thus in *V. Rumphii* the stalk is only one-tenth of the total length of the colony whereas in *V. juncea* it is about two-sevenths of the total length.

In all cases the stalk seems to be composed of two parts, an upper thick-walled muscular part and a relatively thin-walled terminal expanded bulb.

Spicules. In this genus it is perhaps better to leave the spicules out of consideration in the determination of species. It seems probable that *Virgularia* is descended from some ancestral form that had spicules of the usual Pennatulid shape and that the condition we find is due to degeneration. Characters that are degenerating are usually very variable and untrustworthy guides to systematic classification. Spicules are never found in any part of the autozooids,

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rarely in the dorsal track but sometimes in the stalk. When present they are in the form of small granules of various sizes and shapes but never in the form of needles. There is an apparent exception to this general statement in *Virgularia Bromleyi* in which according to KÖLLIKER (1882) the calcareous corpuscles are "of the ordinary form of needles in the stalk, the rachis and the tentacles of the polyps".

The axis. In *Virgularia*, as originally pointed out by RUMPHIUS, the thickest part of the axis is usually at the top or distal end. At the proximal end it tapers to a point and throughout the region of the stalk it is very flexible.

The axis is composed (DALYELL 1848 p. 185) of 85% of inorganic salts, mainly calcium carbonate, and 15% organic substance. The minute structure was described by KÖLLIKER (1865 p. 158 and 1872 p. 187). He pointed out certain difference in detail between the axis of the species he attributed to the genus *Halisceptrum* (now merged with *Virgularia*) and *Virgularia* itself.

There are many practical difficulties in using the axis for systematic purposes. An examination of the whole length of the axis cannot be made without a mutilation of the specimen such as naturalists are loathe to make, and when a specimen has to be preserved for Museum purposes the description of the axis must be scrappy and unsatisfactory.

The surface of the axis of *V. juncea* when dried and examined with a microscope exhibits a number of minute irregular denticulations, that of *V. Rumphii*, *V. Gustaviana*, *V. gracillima* and *V. Roulei* shows definite rows of minute striated ridges (Plate IX, figs 61—63). In *Virgularia rubra* the surface of the axis is smooth but marked by a series of irregular transverse lines.

How far this difference is constant cannot, at present, be ascertained.

Colour. The colour of preserved specimens of *Virgularia* is of little importance. In life they are flesh-coloured, when preserved they are always dull white or pale brown. There are never any of the bright red or yellow colours which render some of the species of *Pennatula*, *Echinoptilum* etc. such beautiful objects for a Museum. The only exception to this statement is to be found in the remarkable red axis of *V. rubra*.

Natural history. Very little is known about the habits of any species of the genus or the appearance they present in the living state. There seems to be very little doubt that the white variety of the Sagitta marina of RUMPHIUS (1705) was a species of *Virgularia* and his account is the first and only one of these sea-pens as seen alive and in their natural surroundings. This species was found off Macassar and at some other localities in the Malay Archipelago living with its stalk imbedded in the sand and a considerable part of the rachis exposed. It has therefore the same erect position as the *Stylatula* described by DARWIN (1889 p. 99) off the coast of Patagonia. When the tide ebbs it burrows deeper into the sand until only two or three inches ("fingers") remain above the ground.

The black variety of Sagitta marina was also regarded by KÖLLIKER (1872) as a species of *Virgularia* (*V. Rumphii*) and of this species RUMPHIUS notes two important and interesting facts.

When the rachis is touched by the hand it causes a painful irritation followed by the appearance of blisters. At night these sea-pens emit a green coloured phosphorescent slime.

It is not remarkable that any sea pen should have the power of stinging or of emitting

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phosphorescent light, but the remarkable point to which attention should be called is that such a careful observer as RUMPHIUS states that he did not observe that the white variety caused an irritation or was phosphorescent. It seems improbable that two closely allied species of the same genus should differ in these respects. The black variety is probably a Pteroeides (HICKSON 1914).

I have carefully examined the nematocysts of specimens of *Virgularia Rumphii* and *V. juncea*, in order to see if there is any marked difference between them, but in both species they are very small (8 μ in diam.) and apparently very simple in structure. It is difficult to believe that in either case they are powerful enough to penetrate the human skin. *Virgularia mirabilis* does not sting.

As regards the power of phosphorescence, it is a remarkable fact that none of the naturalists who have observed and described the living *Virgularia* state that it is phosphorescent. DALYELL (1848 p. 182) who gives an interesting account of the *Virgularia mirabilis* of the Scottish coasts does not record any observation on its phosphorescence although he was well acquainted with this phenomenon in the *Pennatula phosphorea* of the same coast, and more recently HERDMAN (1914 p. 274) who made a special observation on this point remarks that *Virgularia* gives no sign of phosphorescence at all although young Funiculinas dredged along with it are glowing brilliantly.

There is another remarkable feature of the genus *Virgularia* that requires some passing reference. In a very large number of specimens of several species the axis projects beyond the fleshy substance at the distal end of the rachis. The MARSHALLS (1882) considered that this is due to the tops being eaten off by fishes and confirm this view by reference to the observation of Mr R. D. DARBISHIRE that fragments of *Virgularia mirabilis* were found in the haddock's stomach and by the fact that a few specimens were found in which the tops were perfect. In the Siboga collection of specimens of *Virgularia Rumphii* and *V. juncea* there are also a few specimens in which the axis is not exposed at the distal end. BALSS (1910) considers that the rachis is browsed upon by Mollusca but there seems very little evidence to support that view and I am inclined to believe that the MARSHALLS' view is the correct one. It certainly cannot be considered a character of the genus that the axis is exposed at the top of the rachis but it may be that there is some undiscovered quality in the flesh, some want of defensive power or some peculiarity in habits which renders this genus more palatable to marine carnivorous animals than other genera of Pennatulida.

Development. The ova of *Virgularia* are formed on the walls of the coelenteric cavities of the immature leaves at the lower end of the rachis. They may pass from this position into the lateral longitudinal canals and from thence into "the body cavities of fully developed polypes" (MARSHALLS 1882 p. 70).

I have not myself observed eggs ripe or unripe in the fully developed leaves in any of the preparations nor with certainty in the longitudinal canals but it is quite possible that they are to be found in these positions only on the approach of the spawning season. In *Scytaliopsis djiboutiensis* which, in my opinion, is a species of *Virgularia*, GRAVIER (1908) describes and figures the eggs in the longitudinal canals and it is difficult to understand how, in any species of *Virgularia*, they could escape to the exterior without passing along these canals into the

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upper part of the rachis. But if they do this it is not necessary to assume that they escape by way of the mouths of the autozooids. It is possible that they may travel the whole length of the rachis and be discharged at the distal end where the tissues are degenerated.

DALYELL (1848 p. 187) found a number of eggs free in the jars in which the living Virgularias were kept but did not observe their escape. He states that they developed into free-swimming ciliated planulae (sterrulae) and after a time attached themselves by one end and developed tentacles, a stomach and four septa. From this stage of development to the adult there are no direct embryological observations but, by a comparative study of a large number of young specimens, JUNGERSEN (1904 p. 26) has come to the conclusion that they may pass through two or more stages. The first of these is the *Protocaulon* stage which he found in specimens 10—11.5 mm. in length. In this there is a row of solitary autozooid buds on each side of the rachis, and no trace of gonads were found in them. The second stage is the *Deutocaulon* stage, in specimens of 11—40 mm. in length, with two autozooids in each rudimentary leaf. This corresponds with *Deutocaulon hystricis* of MARSHALL and FOWLER (1887 (1) p. 481) whose specimens were 30—48 mm. in length and with the specimen described below as a young Virgularia (p. 174) which was 34 mm. in length. In the last named specimen the gonads are already well developed in the usual position at the base of the rachis.

In a specimen of 60 mm. in length JUNGERSEN found three autozooids in a leaf and, in the series of specimens of *Virgularia gracillima*, I have found the same stage and others with 4, 5 and 6 autozooids until in the largest specimens of 280 mm. in length there were seven autozooids in each leaf.

The general definition of the genus Virgularia might run as follows: —

Long and slender sea-pens with a comparatively short stalk. The rachis provided with a very large number of leaves composed of autozooids of almost equal size. The leaves are usually short, they may meet or overlap on the ventral side of the rachis but leave a well marked track on the dorsal side. In specimens of all ages a very large number of leaves on the proximal part of the rachis are undeveloped and as the rachis approaches the stalk they are represented by rapidly narrowing bands of a few rudimentary autozooids. The dorsal side of the rachis is provided with a system of radial canals. The gonads occur only in the coelenteric cavities of the autozooids of the undeveloped leaves. Spicules are never present in the leaves and are represented, in some forms only, by small oval or irregular calcareous bodies found in the stalk and the dorsal track.

Systematics. There has been a very pronounced tendency among modern writers to reduce the number of genera and species attributed to the family Virgulariidae. It is not necessary fully to discuss the reasons that have led to this desirable result but the more we learn about the variations found in a large number of specimens from a single locality and the different stages of growth of a single species the more certain does it become that many of the genera and species that have been described are only varieties or growth stages of the older species.

There seems little doubt that KÜKENTHAL and BROCH are right in including in the genus *Virgularia* all the species previously described under the following generic names: *Cladiscus* (Koren and Danielssen 1877 p. 100), *Deutocaulon* (Marshall and Fowler 1887 p. 461), *Haliscep-*

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trum (Kölliker 1872 p. 147), *Lygus* (Herklots), *Svava* (Kor. & Dan. 1884 p. 4), and *Svavopsis* (Roule 1908 p. 181) but the *Protocaulon* of KÖLLIKER (1880 p. 26), having generative organs in the fully developed autozooids may be distinct.

It is possible that there may be some difficulty as regards some species, such as *Virgularia (Cladiscus) Studeri* which according to NUTTING (1908 p. 568) has spicules in the walls of the autozooids and the imperfectly known *Virgularia glacialis* of SARS which according to KÖLLIKER (1872 p. 198) has sexual organs in the fully developed leaves; but difficulties of this kind are bound to arise in the case of species that are founded on a single specimen or fragments of a single specimen.

The *Scytaliopsis djiboutiensis* of GRAVIER (1908) may, in my opinion prove to be a *Virgularia*. If so, it is closely allied to if not identical with *Virgularia gracillima*.

The following among the many described species have been carefully studied and illustrated and seem to be undoubtedly distinct.

Name	Authority	Recent reference	Distribution
Virgularia affinis . .	KOREN & DANIELSSEN	KÜKENTHAL & BROCH 1911	Norwegian shores.
V. (C.) cladiscus . . .	JUNGERSEN 1904		N. Atlantic.
V. gracillima	KÖLLIKER	HICKSON. This memoir p. 164	New Zealand and Malayia.
V. (H.) Gustaviana .	HERKLOTS	KÜKENTHAL & BROCH 1911	Tropical seas. (Old world).
V. juncea	LAMARCK	HICKSON. This memoir p. 160	Tropical seas. (Old world).
V. (H.) halisceptrum	BROCH	KÜKENTHAL & BROCH 1911	Red Sea.
V. mirabilis	O. F. MÜLLER	JUNGERSEN 1904	North Atlantic.
V. Reinwardti	HERKLOTS	KÜKENTHAL & BROCH 1911	China seas.
V. (Sp.) Roulei . . .	HICKSON. This memoir p. 168		Malayia.
V. rubra	HICKSON. This memoir p. 167		Amboyna and Banda.
V. Rumphii	KÖLLIKER	HICKSON. This memoir p. 169	Tropical seas. (Old world).
V. Schultzei	KÜKENTHAL	KÜKENTHAL & BROCH 1911	E. and S. Africa.

The following species have been founded on a single specimen, fragments of specimens or have been imperfectly described. Some of them will probably prove to be good species.

Name	Authority	Recent reference	Distribution
Virgularia (H.) abies	KÖLLIKER	BALSS 1910	Japan.
V. (C.) Agassizii . . .	STUDER	JUNGERSEN 1904	Pacific Ocean.
V. (H.) alba	NUTTING 1912		N. W. Pacific.
V. Bromleyi	KÖLLIKER 1880		Japan.
V. (H.) cystifera . . .	NUTTING	NUTTING 1912	California.
V. elegans	GRAY	THOMSON 1905	Ceylon and Australia.
V. (L.) Ellisii	GRAY	KÖLLIKER 1872	New Caledonia.
V. elongata	GABB	KÖLLIKER 1872	California.
V. gracilis	GABB	KÖLLIKER 1872	California.
V. (S.) glacialis . . .	SARS	KÖLLIKER 1872	Finmark.
V. hexangularis . . .	KÖLLIKER 1872		Australia.
V. indica	THOMSON 1905		Gulf of Manaar.
V. kophameli	MAY 1900		S. Atlantic.
V. multicalycina . . .	THOMSON & HENDERSON 1906 (1)		Zanzibar.
V. pusilla	VERRILL 1865	KÖLLIKER 1872	China.
V. (C.) Studeri	NUTTING 1908		Zanzibar.
V. tuberculata	THOMSON & HENDERSON 1905 (2)		Ceylon.

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The recent researches of JUNGERSEN, of BALSS, and of KÜKENTHAL and BROCH have proved that several species, at first regarded as distinct, must be merged with others. Thus: —

Virgularia californica Pfeffer = *V. Reinwardti.*
V. crispa Pfeffer = *V. juncea.*
V. fusca Thomson and Simpson = *V. Rumphii.*
V. (Deutocaulon) hystricis M. and F. = *V. cladiscus.*
V. Loveni Kölliker = *V. mirabilis.*
V. Leuckartii Richiardi = *V. mirabilis.*
V. (H.) magnifolium Roule = *V. (H.) Gustaviana.*
V. microphylla Pfeffer = *V. juncea.*
V. multiflora Kner = *V. mirabilis.*
V. ornata Thomson and Simpson = *V. Rumphii.*
V. (H.) parvifolium Roule = *V. (H.) Gustaviana.*
V. (H.) periyense Thomson and Henderson = *V. abies.*
V. rigida Moroff = *V. juncea.*
V. Steenstrupii Kölliker = *V. affinis.*
V. van Benedenii Herklots = *V. mirabilis..*

The *Pennatula grandis* of PALLAS is the Sagitta marina nigra of RUMPHIUS for which KÖLLIKER gave the name *Virgularia Rumphii.* The *Virgularia australis* of LAMARCK was the name he gave to the Sagitta marina alba of RUMPHIUS now known as *Virgularia juncea.* But there is some confusion in this matter between these early writers as PALLAS gives the name *Pennatula juncea* to the Sagitta marina alba and LAMARCK gives the name *Virgularia juncea* to another species of the genus.

It is often very difficult indeed, if not impossible, to determine what specific name should now be given to the animals described by the writers of the 18th century but there is little reason to doubt that KÖLLIKER was correct in stating that Sagitta marina alba (eerste soort) of RUMPHIUS is the sea-pen now known as *V. juncea.* The description given by RUMPHIUS of his Sagitta marina nigra (tweede soort) however does not correspond with KÖLLIKER's *Virgularia Rumphii* very closely and it may be that it was not a Virgularia at all.

It is true that the specimen examined by KÖLLIKER was found by v. MARTENS on the same spot as that on which RUMPHIUS observed his Sagitta marina nigra namely off the Victoria castle at Amboyna, but apart from this one fact there is no reason to suppose it was a *Virgularia.*

In striking contrast to his description of the leaves of his first kind he described the leaf of this kind as like a cockscomb "doch veel dunder, en uitgebreidt door fyne straalen, in 't rond staande als vischooren, ook mit subtile punten uitsteekende, digt boven malkander, en overdwars aan den worm, doch zoodanig dat men met eenen vinger door tusschen kan komen".

If this sea-pen is really the same as *Virgularia Rumphii* what does RUMPHIUS mean

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by the many fine rays that spread out the leaves and project at the edge like fish fins [1]), and what are the fine points (punten) projecting on the leaves? Moreover is it possible to suppose that RUMPHIUS would be so inaccurate as to say that in this species one could place a finger between the leaves?

My own impression is that what RUMPHIUS was describing was a large Pteroeides.

The specimens described under the name *Scytaliopsis djiboutiensis* by GRAVIER (1908) appear to be a species of *Virgularia*, allied to *V. gracillima* (see p. 159).

The separation of the species of *Virgularia* must in all cases be effected not by a single character but by a combination of characters. The more we learn about any one species the more certain does it become that every character that can be used for purposes of classification is liable to a wide range of variation.

It is quite impossible to draw up a key plan therefore which will enable the zoologist to determine a species with absolute certainty. The plan given by KÜKENTHAL and BROCH (1911 p. 326) is excellent in many ways but is open to criticism. In the first place the distinction between "large leaf-like leaves" and small roll-like (wulstähnlich) leaves is a difference that may be caused by post mortem changes. There are specimens of *Virgularia Rumphii*, for example, in the Siboga collection that would be placed in both these categories and in the second place the statement that there are no siphonozooids on the dorsal track is one that cannot be accepted unless it has been confirmed by several microscopic examinations of horizontal sections.

My own opinion is that the arrangement of the lateral siphonozooids is the most constant and reliable single character for the determination of the species and I have drawn up a key plan of the established species based mainly on this character.

This plan is, nevertheless, also open to criticism, and I will refer to one or two of its weak points. In the first place the distinction between *V. halisceptrum* and *V. Gustaviana* based on the shape of the axis is unsatisfactory, as both cylindrical and four sided axes may occur in the same species (e. g. *V. Rumphii*). If this distinction is supplemented by the presence of siphonozooids on the dorsal track in the former and their absence in the latter as stated by KÜKENTHAL and BROCH the species are undoubtedly distinct but I venture to doubt whether in any of the large fleshy Virgularias the siphonozooids are really absent on the dorsal track.

In the second place species that usually exhibit two or three rows of siphonozooids between the leaves may occasionally be found with only one row. The specimen of *V. Rumphii* for example described by KÖLLIKER had only one row and one specimen in the Siboga collection that shows close affinities with the same species has only one row.

The disadvantage which this and all other key systems possess is that being artificial it does not in any sense indicate the affinities of the species.

Virgularia Reinwardti, *V. Rumphii*, *V. Roulei*, *V. Gustaviana* and *V. halisceptrum* are closely related, but *Virgularia juncea*, *V. Schultzei* and *V. gracillima* are quite distinct from each other and from the other two groups.

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1) Professor WEBER has suggested to me that the word "vischooren" or "fish-ears" used by RUMPHIUS probably means the opercula.

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Key plan of species of *Virgularia*.

A. With teeth or tubercles on the margin of the calyx . . . . . *V. cladiscus*
B. Without teeth or tubercles on the margin of the calyx.
I. The lateral siphonozooids on the leaves . . . . . *V. Schultzei*
II. The lateral siphonozooids between the leaves.
α. In a single row
1. Equal in number to the autozooids . . . . . *V. Reinwardti*
2. Fewer than the autozooids
* Autozooids 35 ± . . . . . *V. juncea*
** Autozooids 7 ± { Axis ridged . . . . . *V. gracillima*; Axis smooth . . . . . *V. rubra*
β. In two or three rows
1. Autozooids very numerous and arranged in clusters . *V. Roulei*
2. Autozooids numerous. Not in clusters. Leaves with an S-shaped bend . . . . . *V. Rumphii*
3. Autozooids 10 ± . . . . . *V. mirabilis* [1])
γ. Siphonozooids in many rows
1. Autozooids 100 ±
* Axis cylindrical, Autozooids 70—100. . . . . *V. halisceptrum*
** Axis four-sided, Autozooids 100—200 . . . . *V. Gustaviana*
2. Autozooids 6—10 . . . . . *V. affinis.*

I may add here a few remarks on two genera of Virgulariidae that are by some authors regarded as distinct.

The genus *Scytaliopsis* was founded by GRAVIER (1908 p. 236) on specimens obtained in very shallow water in the gulf of Tadjourah. They are very slender pennatulids which do not attain to a length of more than 100 mm. Like *Virgularia* they have on each side of the proximal end of the rachis a long row of immature leaves and it is in this region of the rachis that the genital products are formed. The distal end of the rachis is probably, judging from the description and figures given by GRAVIER, degenerate and he has shown by some very interesting experiments on the living animal that when the water in the aquarium is lowered so that the distal end of the rachis is exposed the living tissues slide down the rachis so as to leave the axis exposed. There are five autozooids in each leaf and there are no spicules in any part of the rachis. Finally on the dorsal side ("ventral" according to GRAVIER's nomenclature) there is a series of ciliated tubes corresponding in position with the radial canals of *Virgularia*.

In all these characters this sea-pen appears to be a true *Virgularia*, and in all of them, except the long row of immature leaves, it differs from *Scytalium*.

KÜKENTHAL and BROCH (1911 p. 305) say that in their opinion *Scytaliopsis* is allied to

1) In small forms of *V. mirabilis* there is only one row of siphonozooids and the species is then difficult to distinguish from *V. Reinwardti*.

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Scytalium in the character that new autozooids are formed on the ventral side of the leaf during its growth. This is not a character which distinguishes either genus from *Virgularia*. In all the species of *Virgularia* I have examined new autozooids are added on the ventral side of the leaf during its growth but it is particularly noticeable in those species such as *Virgularia gracillima* in which the total number of autozooids in a mature leaf does not exceed five.

There are however three or four points in which *Scytaliopsis* differs from any species of *Virgularia* I have studied. There are only two siphonozooids between two successive leaves on each side of the rachis and one of these on the ventro-lateral track appears to be of a remarkably large size. The mouth of each of these is surrounded by a circular sphincter muscle and the cavity opens directly into the ventral longitudinal canal. Such a condition of a siphonozooid cavity opening directly into one of the great longitudinal canals only occurs in the mesozooids of certain species of *Pennatula* and in *Pteroeides* (see p. 11). It would be extremely interesting if it were proved that this type of zooid also occurs in *Virgularia*.

Another feature of importance is the statement that the radial canals open directly to the exterior. The figure that GRAVIER (Plate VIII, fig. 78) gives to illustrate this point does not convince me that the statement is correct, but it must be remembered that he had the advantage of examining the species alive and watching the ciliary currents of the epithelium that lines these tubes.

Neither the peculiarity of the large ventral siphonozooids nor the supposed opening of the radial canals to the exterior appear to me to be good characters upon which to found a new genus, and I regard *Scytaliopsis* therefore as a synonym of *Virgularia*.

If *Scytaliopsis* is a true Virgularia it is clearly related to *V. gracillima*, in fact, apart from the characters referred to above, the description and figures of *Scytaliopsis djiboutiensis* correspond very closely with some of the specimens of this species collected by the "Siboga".

However as GRAVIER's specimens did not exceed 100 mm. in length and may therefore be young forms of another species and as the Gulf of Tadjourah is a long way away from the only localities in which *V. gracillima* has been found it is possible that they represent a distinct species.

The genus *Stephanoptilum* proposed by ROULE (1905) for some specimens obtained by the Talisman from 930—2000 metres in the Atlantic is also probably a member of this family. The preliminary account which is not illustrated by figures does not give sufficient information to enable me to allot to it a definite place in our system. From the brief description, its characters do not seem to be inconsistent with those of a *Virgularia* and as the autozooids in the upper part of the rachis are arranged in tufts or bunches on oblique zones of attachment, it may be closely related to the *Svava glacialis* (Marshall and Fowler) which is, according to JUNGERSEN, identical with *Virgularia cladiscus*.

1. *Virgularia juncea* (Pallas). (Textfigs 33 and 34).

Pennatula juncea Pallas 1766. Elenchus zoophytorum. p. 371.
Not *Virgularia juncea* Lamarck 1816. Animaux s. vertèbres. II, p. 431.

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Virgularia juncea Kölliker 1872. Die Pennatuliden. p. 206, Taf. XIII, fig. 105.
Virgularia juncea Kükenthal and Broch 1911. "Valdivia" Pennatulacea. p. 343.

Stat. 163. Seget reef, New Guinea.
Stat. 174. Waru reef, Ceram. 4 Ex.
Stat. 213. Saleyer anchorage. —36 metres. 34 Ex.
Stat. 272. Dobo reef, Aru islands. 2 Ex.

There can be little doubt that this species is the same as the Sagitta marina (eerste soort) of RUMPHIUS. It was found by him at Hitoe on the coast of Kaytetto at Lokki and Laola [1]) on the coast of Hoeamohel and also off the coast at Makassar.

It has since been described by several authors from the Malay and Indian seas in shallow water and is evidently a common and widely distributed species.

PFEFFER (1886 p. 57) describes two new species *V. microphylla* and *V. crispa* from the Sulu sea which it is important to note were collected with many specimens of *V. juncea*. In the former the leaves are said to be not so strongly developed being only 2.6 mm. in height.

The study of the 34 specimens from Saleyer is sufficient to convince any one that the principal characters used for distinguishing these two new species are satisfactory, but apart from that, it would be a very remarkable thing if isolated specimens of two distinct but closely related species were to be found living among a crowd of specimens of a third and also closely related species of the same genus.

I agree with KÜKENTHAL and BROCH in regarding PFEFFER's two species as synonyms of *V. juncea*; but there is some doubt whether MOROFF's (1902) *Virgularia rigida* from the Philippines should be so regarded. BALSS considers *V. rigida* to be the same as *V. Reinwardti* but KÜKENTHAL and BROCH's analysis seems to show that it may be *V. juncea*.

Of the 42 specimens of this widely distributed genus only five seemed to be uninjured. In all the others the axis projected beyond the soft parts at the distal extremity. The five uninjured specimens were 474, 450, 325, 250 and 155 mm. respectively in total length. The largest but nevertheless imperfect specimen came from the Dobo reef and was 580 mm. in length. In comparing the species with *Virgularia Rumphii* there is a noticeable difference in their relative length. Five specimens were selected from those that seemed to be uninjured or slightly injured and their average length was found to be 325 mm. the average length of the stalks being 95 mm.

That is to say the stalk is about two-sevenths of the total length whereas in *V. Rumphii* it is only a little over one-tenth.

The diameter of the rachis including the leaves is about 4 mm. in its widest part and I have found very little variation from this measurement. Just below the rachis the stalk is only 2—3 mm. in diameter but is much wider in the region of the muscular and membranous swellings.

The following measurements of the largest specimen in the collection namely one of the specimens from the Dobo reef may be of interest in this connexion.

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1) I am informed by Prof. MAX WEBER that Kaytetto is on the coast of Amboyna island and that Lokki and Laola are on the coast of Ceram.

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Total length	580 mm.
Length of stalk	142 „
Diameter of rachis	4.6 „
Length of muscular swelling of the stalk	80 „
Length of membranous swelling of the stalk	62 „
Greatest diameter of muscular swelling	7 „
Greatest diameter of membranous swelling	12 „

This is the largest specimen of the species on record. The next to it in size is one described by KÖLLIKER from the Philippine islands which was 499 mm. in length. Prof. MAX WEBER has shown me some fine specimens of this species, of which the largest is 340 mm. in length, collected by him at Pare Pare in Celebes in 1888.

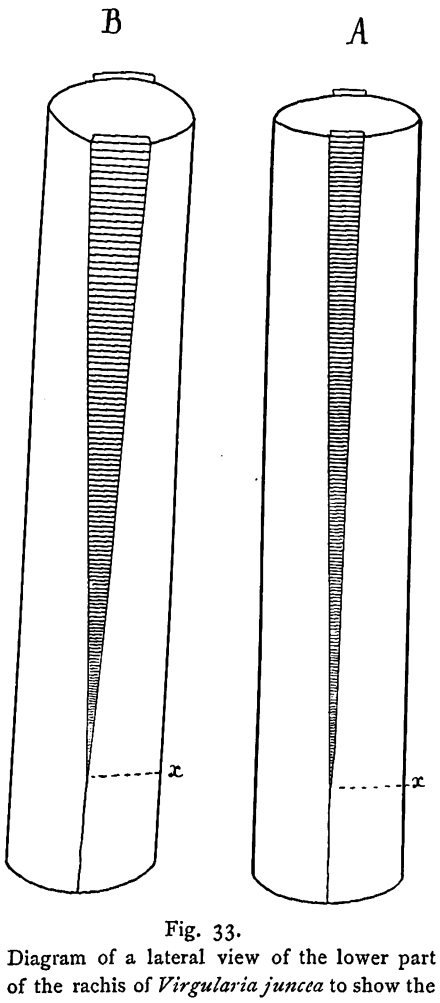

Fig. 33.
A. Diagram of a lateral view of the lower part of the rachis of *Virgularia juncea* to show the diminution in width of the immature leaves.
B. Diagram of a lateral view of the lower part of the rachis of *Virgularia Rumphii* to show the diminution in width of the immature leaves.
x represents the point where the young leaves disappear in the groove.

The leaves of this species are very narrow — a characteristic feature — the length of the autozooids rarely exceeding 1—2 mm. and unless the specimen is badly contracted the leaves do not overlap.

The leaves are further distinguished from those of *V. Rumphii* by the absence of any S-shaped flexure.

The stalk. At the point where the undeveloped leaves disappear in the lateral groove of this rachis the diameter of the pen contracts. In some cases this contraction is like a sphincter muscular contraction and marks the boundary line between rachis and stalk very clearly.

Below this constriction the upper or muscular swelling of the stalk begins. It increase in diameter for about two-thirds of its length and then contracts again to its termination. The membranous swelling is usually about $^3/_4$ the length of the muscular swelling and may have a diameter nearly twice as great but these structures are so obviously distorted in various ways by preservation that it is impossible to give reliable figures of their true measurements. The only point of interest is that, in comparing the large number of specimens of this species with the large number of specimens of *V. Rumphii* collected by the Siboga expedition, the greater relative diameter of the two swellings in *V. juncea* seems to be a character of some specific value.

The number of autozooids in the mature leaves shows some variation. In the large specimen from the Dobo reef I have counted as many as 30, in a specimen 474 mm. in length from Saleyer 19—20 and in a smaller specimen 18—19. The number seems to vary to some extent in the mature leaves of a single specimen and when trying to get an average for the species I found that smaller specimens some times have more autozooids in their leaves than larger ones. The

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average number of autozooids in a leaf of ten specimens from Saleyer came out as 21; but the number may range between 15 and 30 in specimens of over 300 mm. in length.

KÖLLIKER gives the number of autozooids in the species as 11—15 and KÜKENTHAL and BROCH a range of 7—35.

The autozooids themselves do not present any features of special interest, but in their average length from the tip of the calyx to the base of insertion they are shorter than in *V. Rumphii*. The longest autozooids on a large specimen I measured were not more than 1.5 mm. in length. I have not observed any autozooids in this species with the tentacles expanded.

The number of immature leaves is very much greater in proportion to the length than in *V. Rumphii* and the leaf situated at a distance of 20 mm. from the point of disappearance of the leaves is only 1 mm. in width (cf. *V. Rumphii* p. 162, textfig. 33).

The siphonozooids are arranged in a single horizontal row between the autozooids and are decidedly larger than they are in *V. Rumphii*. By making a series of horizontal sections through the bases of two or three leaves with the intervening part of the rachis of several specimens two features can be clearly demonstrated.

Firstly there is never more than one siphonozooid corresponding with the base of an autozooid in the leaf above it (textfig. 34, 2.). In many preparations it seems as if there is generally only one siphonozooid to two autozooids but in one preparation I have counted 14 siphonozooids to 18 autozooids. It is quite clear however that there are never as many siphonozooids as there are autozooids in the leaf immediately above them.

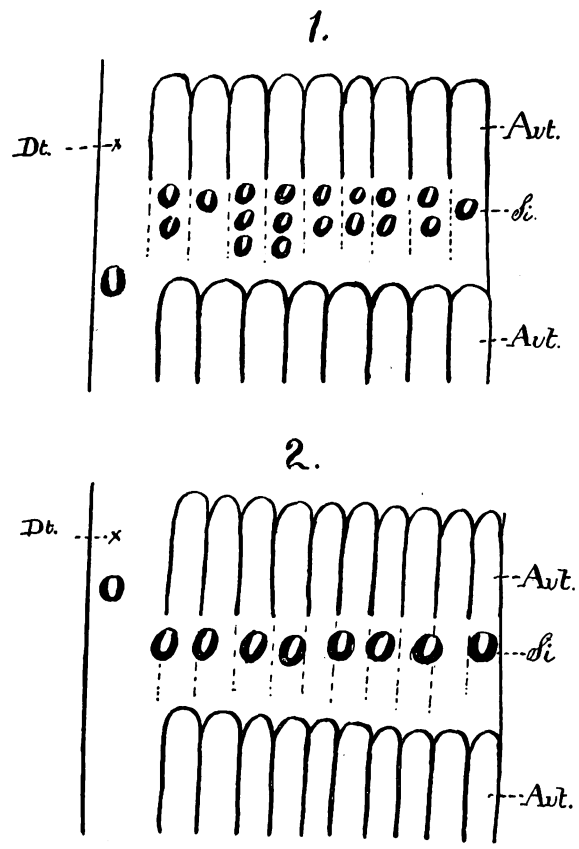

Fig. 34.

1. Diagram of arrangement of siphonozooids in *Virgularia Rumphii*. *Aut.*, *Aut.* two leaves of autozooids. *Si.* the siphonozooids. *Dt.* the dorsal track. The dotted lines represent the walls separating the body cavities of the autozooids between the leaves. There is one or more than one siphonozooid to each autozooid. On the dorsal track *Dt.* there is seen one isolated siphonozooid.
2. Diagram of the arrangement of siphonozooids in *Virgularia juncea*. *Aut.*, *Aut.* two leaves of autozooids. *Si.* the Siphonozooids. *Dt.* the dorsal track. The dotted lines represent the position of the walls separating the body cavities of the autozooids between the leaves. There are fewer siphonozooids than autozooids. On the dorsal track there is seen one isolated siphonozooid.

In addition to these siphonozooids between the leaves a single siphonozooid may occasionally be found on the dorsal track, sometimes but not always in a position corresponding to an interval between the leaves as if it were a continuation of the horizontal row extending on to the track. It is difficult to determine whether their presence is a constant feature of the species as I have not been able to see them with certainty except in a series of sections, but that siphonozooids of this kind, having a similar relation to subjacent structure as they have in *Virgularia Rumphii*, do occur in some specimens there can be no doubt.

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Axis. In general shape the axis of this species is very similar to that of *V. Rumphii*. On taking a number of measurements it is found however that the average diameter at the distal end is about 1.75 mm. or measurably smaller than in that species.

The surface when examined by reflected light is seen to be provided with a number of short tubercles or tooth-like projections arranged in longitudinal rows but not striated as in the other species (Plate IX, fig. 62). I have carefully examined this character in a large number of specimens collected by the Siboga and in the various Museums and it appears to be constant.

Spicules. KÜKENTHAL and BROCH (1911 p. 345) describe the stalk spicules of this species as some giant oval forms 0.045 mm. in length and others 0.02 mm. I also have found spicules only in the stalk. In two specimens examined there were a few oval forms 0.02 mm. in length and others 0.015 × 0.003 mm. and less in measurement. They are not very numerous.

The general definition of the species may read as follows: —

Long and slender colonies with numerous rather short leaves composed of about 35 autozooids in the larger colonies. Siphonozooids in a single row between the leaves and fewer in number than the autozooids in the corresponding leaves. Axis cylindrical with a surface marked by short unstriated tubercles arranged in longitudinal rows.

2. *Virgularia gracillima* Kölliker. (Pl. IX, figs 61 & 64 and Textfig. 35).

Virgularia gracillima Kölliker 1880. "Challenger" Pennatulida. p. 10, Pl. III.
Virgularia gracillima Dendy 1896. Trans. and Proc. N. Zealand Institute. XXIX, p. 256.
Virgularia aff. Bromleyi Kükenthal and Broch. 1911. "Valdivia" Pennatulacea. p. 12, Fig. 57.
? *Protocaulon molle* Kölliker 1880. "Challenger" Pennatulida. p. 26.

Stat. 71. Makassar. 1 fragments.
Stat. 181. Amboyna anchorage. 4 fragments.
Stat. 206. 4° 58′ S., 122° 42′ E. Buton strait. 51 metres. 7 Ex.
Stat. 285. 8° 39′ S., 127° 4′ E. Timor. 34 metres. 1 young Ex.
Stat. 321. 6° 5′ S., 113° 30′ E. Off Madura. 82 metres. 16 Ex.

The species was originally described by KÖLLIKER from a single specimen obtained by the "Challenger" expedition in 18 metres near Long Island, New Zealand. The specimen was imperfect and 77.5 mm. in length.

In the description of the "Porcupine" Pennatulids, MARSHALL and FOWLER (1887 p. 462) suggest that the species may be the same as the form described by them as *Deutocaulon hystricis*; but JUNGERSEN (1910 p. 31) gives reason for believing that "Deutocaulons" are the young forms of either *Virgularia mirabilis* or of *V. cladiscus*.

Neither KÖLLIKER, DENDY nor MARSHALL and FOWLER describe the siphonozooids of their specimens and consequently it is possible to determine with absolute certainty whether the Siboga specimens are identical with the previously described species or not. A comparison between the type specimen in the British Museum and the Siboga specimens does not justify the construction of a new species at present and I can only say that in my opinion there is a strong probability that the identification is correct.

KÜKENTHAL and BROCH (1911 p. 342) give a description of a specimen from Lyttelton

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harbour, New Zealand in the Vienna Museum which he says is allied to *Virgularia Bromleyi* of KÖLLIKER. It seems probable to me, from the locality of the Vienna specimen and from the study of the 23 specimens in the Siboga collection that it belongs to the same species as that described by DENDY and referred by him to the species *V. gracillima*.

The figures (Pl. XXI, fig. 57) given by KÜKENTHAL and BROCH of their specimen are not in agreement with the figures given by KÖLLIKER (Pl. III, fig. 10) of *Virgularia Bromleyi* in which the wide distance (4 mm.) that separates the leaves of the latter species is clearly shown. Moreover KÖLLIKER's description of the spicules "of the ordinary form of needles 0.085 mm. maximum length" is not in agreement with the statement and figures of the spicules in the Vienna specimen. On the other hand the excellent description by KÜKENTHAL and BROCH of the details of structure are in close agreement with the larger specimens of *V. gracillima* in the Siboga collection.

The specimens in the Siboga collection from the two Stations 206 and 321 seemed at first sight to be different. Those from Buton are pale brown in colour and larger in size, those from Madura are white with a pale yellow stalk and smaller in size.

The following measurements however show that in the matter of size the specimens from the two localities overlap: —

Total length in mm. of the 7 specimens from Buton 280, 230, 220, 193, 140, 120, 85.
Total length in mm. of the 7 specimens from Madura 168, 108, 103, 88, 75, 72, 55.

A comparison of the specimens of a similar length from the two localities leaves little doubt that they belong to the same species.

They may be described briefly as slender and delicate sea pens with small leaves composed of a few autozooids which, in the middle region of the rachis, usually have their tentacles expanded. The largest specimen from Buton 280 mm. in length has a stalk 43 mm. in length.

The diameter of the rachis is about 3 mm. The stalk consists of a muscular swelling 29 mm. in length with a maximum diameter of 2 mm. and of a terminal membranous swelling 14 mm. in length and a diameter of 3 mm.

The leaves in the specimens examined are almost opposite to one another and meet but do not overlap on the ventral side. In the larger specimens the leaves are about 2 mm. apart.

The number of autozooids in each leaf varies according to the size of the specimen. In the largest specimen from Buton there were 7 autozooids in many of the leaves, in the specimen from Buton 85 mm. in length there were not more than 2. The number of autozooids in KÖLLIKER's specimen was 4 and DENDY says of the specimens he examined "Most of the pinnules contain four polyps but the number varies somewhat".

The autozooids stand out almost at right angles to the rachis and are not inclined distally at an acute angle as in most of the species of the genus. They are not more than 1 mm. in length and are united together only for a distance of about 0.5 mm. from their base. In all but the smallest specimens the tentacles of the autozooids are extended.

The siphonozooids are very difficult to see in the ordinary spirit specimens and

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they have not been previously described either by KÖLLIKER or by DENDY for the species or by MARSHALL and FOWLER for *Deutocaulon*.

The study of stained preparations however shows that there are in the large specimen (280 mm.) three or four siphonozooids (fig. 35) situated about half way between the leaves in an oblique row. In some of the smaller specimens I have been able to find only one or two. In all cases however the number of siphonozooids is less than the number of autozooids in the leaves above and below them and there is a considerable distance between the siphonozooids and the nearest leaf.

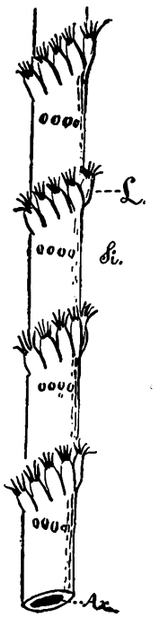

Fig. 35. *Virgularia gracillima.* A portion of the rachis to show the position of the siphonozooids *Si.* *L.* leaves. *Ax.* axis. × 10 diam.

Neither in whole mount preparations nor in series of sections have I been able to discover any siphonozooids on the dorsal track.

The axis is very slender, in the largest specimen only 0.75 mm. in diameter. It is cylindrical in shape and shows a surface structure similar to that of *V. Rumphii*.

Spicules. In one of the specimens examined I found several spicules in the muscular and membranous parts of the stalk (Pl. IX, fig. 64). They are of two kinds, large oval, isolated spicules .005 × .010 mm. and much smaller ones of irregular size and shape arranged in clusters. These clusters of spicules are about .015 × .020 mm. in size. In another specimen no spicules were found. KÖLLIKER, whose specimen has no stalk, does not mention the spicules but DENDY says that there are none.

Radial canals. In whole mount preparations a series of darkly stained oval bodies may be seen lying below the cortex on the dorso-lateral aspect of the rachis.

The number of these varies from six to twelve or more, between successive leaves. In such a preparation they might be mistaken for large siphonozooids or possibly gonads. In transverse section, however, they are found to be large canals similar in histological structure to the radial canals of the other species of the genus but there is only one instead of a number of them on each side of the dorsal track. They do not open directly to the exterior but communicate with the coelentera of the siphonozooids by large endodermal canals, as in the other species, and open internally into the dorsal longitudinal canals. My preparations of these structures call to mind very forcibly the "parietal canals" (GRAVIER 1908 p. 247) of *Scytaliopsis* although in this genus they are said to open directly to the exterior.

Similar structures to these were found in preparations of the young *Virgularia* from Station 294 (p. 174) and of the *Virgularia* sp.? from Stat. 51. The specimens from the last named station are beautifully preserved in formol and the radial canals can be seen quite clearly by transmitted light without clearing in oil. They are also present in the same form in *V. rubra*.

The species may be defined as follows: —

Small and very slender Virgularias with pairs of leaves separated by considerable intervals composed of 3—7 autozooids according to the size. Autozooids united only at the base and

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usually expanded in preserved specimens, without calyx or tubercles. Siphonozooids in a single row between the leaves, fewer in number than the autozooids of the neighbouring leaves. Axis very slender and marked by striated surface ridges.

3. *Virgularia gracillima* (?) Kölliker.

Stat. 77. 3° 27′ S., 117° 36′ W. Borneo bank. 59 metres. 1 specimen.

This specimen differs in some respects from the specimens collected in Buton Strait and off Madura.

For a specimen of its length (220 mm.) it is very slender, the number of autozooids in each leaf comparatively small, and the autozooids themselves very short. It is clearly more closely related to *Virgularia gracillima* than it is to any other species of the genus, but it is possible that if other specimens showing similar characters are discovered and a more thorough study of its anatomy is made it may prove to belong to a distinct species.

The total length of the specimen is 220 mm. and of this about 30 or 40 mm. may be attributed to the stalk which however is broken at the proximal end. The greatest breadth of the rachis including the leaves is only 2 mm.

The leaves are in the form of short ridges on the lateral sides and do not meet on the ventral side of the rachis. They are separated from one another on each side by a distance of about 1 mm.

Each leaf in the middle region of the rachis consists of five autozooids.

The autozooids are fully expanded, not more than 0.5 mm. in length and united only at their bases by a shallow ridge.

The siphonozooids are arranged in a single row of three or four between the leaves and no siphonozooids were observed on the dorsal track. As the siphonozooids are very difficult to see except in stained preparations and as this statement is made on the result of only two observations, it may need some amendment. However, it may be taken as sufficient to show that there is no important difference between this specimen and the specimens of *Virgularia gracillima* in the collection as regards the arrangement of the siphonozooids.

The axis is cylindrical and appears to have the same texture as the other specimens.

As it seemed possible that the specimen might be a young form of some much larger species I examined it specially for the gonads. The gonads were found only in the region of the immature leaves as in the other species of the genus. It proved to be a male but I was surprised to find that the spermatozoa were quite ripe.

It is not suggested that this fact proves that the specimen is fully grown but it does to some extent support the view that the adult form could not be regarded as a distinct species.

4. *Virgularia rubra* n. sp. (Pl. VII, figs 46 & 47).

Stat. 181. Amboyna anchorage. —54 metres. Several fragments.
Stat. 240. Banda anchorage. 9—30 metres. 2 fragments.

I am unable to describe this species fully as the specimens are broken.

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It is clearly allied to *Virgularia gracillima* but differs from this species in the number of autozooids in a leaf and in the colour and texture of the axis. There might have been some hesitation in separating it from *V. gracillima* but for the fact that specimens of the two species were obtained in the same locality (Amboyna anchorage) and a comparison of them shows constant and striking differences.

The largest specimen, 230 mm. in length, was obtained from Banda but the stalk is broken at the end and no trustworthy measurement can be given of its length.

One of the fragments from Amboyna is a part of what was probably a still larger specimen, but it consists of rachis only and is 215 mm. in length and 3 mm. in diameter.

There is, in the series from Amboyna, a specimen which probably represents the greater part of a young colony and this is 26 mm. in length. Judging from the larger fragmens the principal characters of the species are as follows: —

The larger leaves are opposite or alternate composed of 8—12 autozooids.

The autozooids are widely separated for a distance of half their length and when retracted form long oval calices (Pl. VII, fig. 47). The length of the largest autozooids measured from the base of the leaf is 3 mm. The tentacles are 1 mm. or more in length when fully extended and provided with numerous long delicate pinnules. The mature leaves are fan-shaped with a very narrow base of insertion (Plate VII, fig. 46).

The siphonozooids are arranged in a single row between the leaves and are fewer in number than the autozooids of the corresponding leaves. There are no siphonozooids on the dorsal track.

The axis is cylindrical and in all the specimens has an orange-red or pink colour, which when dried, turns brown.

The surface of the axis when dried does not show the longitudinal striated ridges that are seen in *V. gracillima* and some other species (see p. 173) but is quite smooth showing only transverse lines which seem to divide it into series of more or less irregular discs.

I have examined a considerable number of preparations of the axis of this species and of *V. gracillima* from the same locality. The difference between them is most striking. The red-colour and smooth surface of the former and the white colour and rough surface of the latter being apparently quite constant characters.

Preparations show that in this species the radial canals are very well developed.

5. *Virgularia Roulei* nov. nom. (Pl. VII, figs 44 & 45).

Syn. *Svavopsis elegans* Roule 1908. Alcyonaires d'Amboine. p. 184, Pl. VIII.

Stat. 99. North Ubian anchorage. 16—23 metres. 1 fragment.
Stat. 133. Off Lirung Talaut Islands. 36 metres. 2 fragments.
Stat. 181. Amboyna. Reef collection. 1 Ex.
Stat. 240. Banda. 9—36 metres. 1 fragment.

The type specimen of this species came from Amboyna and was described by Roule.

Kükenthal and Broch (1911 p. 325) have given reasons for believing that the species cannot be separated from the genus *Virgularia* and with that view I am in cordial agreement.

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It may be a matter of some doubt whether the species should be regarded as a variety of *V. Rumphii* to which it undoubtedly shows strong affinities but it appears to me advisable at present to regard it as distinct.

As the name *Virgularia elegans* is preoccupied I propose to give the species the new name *Virgularia Roulei* as a compliment to the distinguished French author whose excellent description and figures of his specimen are so valuable in the discussion of the affinities of the species.

The character upon which ROULE relies for the generic distinction of *Svavopsis* from *Virgularia* is that in the former the autozooids are arranged in groups and not in true leaves ("lames"). It is quite clear from the study of ROULE's figures that the autozooids are very crowded together on transverse areas of the rachis, that they have a general resemblance to the leaves of such species of Virgularia as *V. Rumphii* and *V. juncea* and that, although the continuity of the leaves may be broken, it is inconceivable that all the autozooids are seated independently on the sides of the rachis.

It cannot be doubted that there is leaf formation in *Svavopsis* although it may present the unusual feature of discontinuance in some of the leaves. This feature, standing by itself, does not appear to be sufficient to constitute a new genus. In all other characters but this the species is a typical Virgularia.

The species is represented in the collection by one complete specimen from Amboyna, some pieces of two specimens from Lirung and a fragment from the Sulu islands. The complete specimen is 220 mm. in length of which 85 mm. may be attributed to the stalk. The membranous swelling at the base of the stalk is 20 mm. in length and 12 mm. in diameter.

The largest fragment from Lirung is 115 mm. in length with a breadth of 5 mm. the smaller is 65 mm. in length with a breadth of 3 mm.

The leaves are composed of a large number of autozooids about 35 in the larger specimen, densely crowded together showing in many places a distinct arrangement in groups.

An interesting point in connexion with these specimens is that, as in the type, some of the autozooids are expanded. This is a character which in all Alcyonaria should be used with caution, but as there is no reason to suppose that these specimens were preserved with special care and as the autozooids of none of the specimens of *V. Rumphii* and *V. juncea* are expanded, it may be not unimportant.

The siphonozooids are arranged in two or three transverse rows between the leaves as in *V. Rumphii* and there are some clearly marked siphonozooids on the dorsal track.

The axis is 4 sided with rounded edges. In this respect the specimens differ from the type of the species in which it is round in section. The surface texture of the axis is the same as in *V. Rumphii*.

5. *Virgularia Rumphii* Kölliker. (Pl. IX, fig. 63 & textfigs 33 B & 34, 1).

Virgularia Rumphii Kölliker 1872. Die Pennatuliden. p. 202, Pl. XIII.
Virgularia Rumphii Marshall & Fowler 1887. Mergui Pennatulids. p. 277.
Virgularia Rumphii Roule 1908. Alcyonaires d'Amboine. p. 181.

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Virgularia Rumphii Thomson & Crane 1909. Alcyonaria of the gulf of Cutch. p. 134.
Virgularia ornata Thomson & Simpson 1909. "Investigator" Alcyonaria. p. 281.
Virgularia fusca Thomson & Simpson. 1909. "Investigator" Alcyonaria p. 281.
Virgularia Rumphii Kükenthal & Broch 1911. "Valdivia" Pennatulacea. p. 337.
? *Virgularia calycina* Thomson 1905. Ceylon Alcyonaria. Appendix p. 180.
? *Virgularia abies* Balss 1910. Japanische Pennatuliden. p. 46.

Stat. 51. Molo Strait. 69—91 metres. 1 fragment.
Stat. 99. Sulu Archipel. 16—23 metres. 1 fragment.
Stat. 115. Kwandang Bay. Reef. 1 fragment.
Stat. 121. Menado anchorage. 55 metres. 15 Ex.
Stat. 174. N. Coast of Ceram. Reef. 1 fragment.
Stat. 258. Kei Islands. 22 metres. Several fragments.

KÖLLIKER was of the opinion that the second kind (tweede soort) of the Sagitta marina of RUMPHIUS was the same as that described by him as *Virgularia Rumphii*. There are some difficulties in accepting this view (p. 157) but if it is correct, then, it is the same species as that described by PALLAS in 1766 under the name *Pennatula grandis*.

The description given by KÖLLIKER was based on a single specimen in the Amsterdam Museum obtained from Amboyna. The more recent description of the species by KÜKENTHAL and BROCH (1911 p. 337) was also based on the examination of one specimen in the Vienna Museum from Amboyna.

Other specimens attributed to the species are one specimen from Amboyna (ROULE 1908 p. 181) two specimens from the Gulf of Cutch (THOMSON & CRANE 1909 p. 134) and three specimens from the Mergui Archipelago (MARSHALL and FOWLER 1887 p. 277). There is also a very large specimen named *V. Rumphii* in the Museum at Leiden collected by Dr. HOEDT at Amboyna in 1866.

In the Siboga collection there are fortunately no less than fifteen specimens from one locality and as it seems highly improbable that in this gathering more than one species is represented the collection has afforded me an opportunity of studying some of the possible variations of form that the species may assume.

It is for this reason that I am inclined to support KÜKENTHAL and BROCH's opinion that *Virgularia ornata* and *V. fusca* (Thomson & Simpson 1909 p. 281) from the Andaman islands should be merged with *V. Rumphii*.

Virgularia ornata was described from a portion of a colony only and it apparently differs from *V. Rumphii* in having an axis that is quadrilateral in section. It is true that a quadrilateral axis has not yet been described in any specimen of *V. Rumphii* but I do not feel certain that such a character might not appear as a local variation or as the result of some malformation.

In having "the zooids in three or four rows" it resembles and does not differ from the Siboga specimens of *V. Rumphii*.

The species described as *Svavopsis elegans* by ROULE (1908 p. 184), which KÜKENTHAL and BROCH regarded as closely related to if not identical with *V. Rumphii*, is in my opinion a distinct species of Virgularia (see p. 168).

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Virgularia fusca, described from a single specimen, has a large number (60—65) of autozooids on each leaf but I do not consider this character nor the absence of spicules sufficient to constitute a new species.

It is unfortunate that no figures have been published of either *Virgularia ornata* or *V. fusca* and consequently it is exceedingly difficult to determine whether they are distinct or not in the light of the new investigations here recorded.

I would also venture to doubt whether the pennatulids described under the names *Virgularia abies* by BALSS (1910 p. 46) from Japanese waters, 20 metres, and *Virgularia calycina* by THOMSON (1905 p. 180) from Ceylon seas are really distinct from *V. Rumphii.*

Nearly all the specimens of the species collected by the Siboga expedition at the Menado anchorage were imperfect at the distal extremity and, at the proximal end, the contraction in preservation has caused the axis to protrude for a distance of 10—20 mm.

The total length of three perfect specimens varied from 190—350 mm. It is quite certain however from an examination of some obviously imperfect specimens that the total length frequently exceeds 400 mm. The specimen in the Museum at Leiden which undoubtedly belong to this species is about 600 mm. in length.

The total length of the specimen examined by KÖLLIKER was 532 mm. but the longest specimen on record is one described by MARSHALL and FOWLER (1887 p. 277) which was 905 mm. in length.

It is noteworthy that RUMPHIUS described his specimens of the second kind of Sagitta marina as 2 to $2^1/_2$ feet in length (610—750 mm.) as compared with the first kind (i. e. *V. juncea*) which were 1 to $1^1/_2$ feeth in length. In the Siboga collection the average length of the specimens of *V. juncea* is greater not less than that of the specimens of *V. Rumphii.*

If we take 400 mm. as the total length of a large specimen from Menado I have reckoned that about 40—45 mm. may be attributed to the stalk and the remainder to the rachis.

The diameter of this pennatulid varies very considerably according to the state of contraction in which the specimens were preserved, but, for comparison with other species described it may be noted that the greatest diameter of the rachis including the leaves of six specimens varied from 5—8 mm. and of the stalk from 3—5 mm. The rachis is therefore wider in this species than in *V. juncea.*

The stalk in nearly all the specimens, is very much altered by post-mortem changes. In one uninjured specimen however there is a terminal thin-walled bulbous expansion 9 mm. in length by 6 mm. in diameter. Above this, the stalk has a thick muscular wall and is almost uniform in diameter up to the point where it joins the rachis. The stalk is relatively short in all the specimens. Taking the average of the three uninjured specimens it was found that the stalk was about one-tenth of the total length.

The leaves. It is impossible to state accurately the number of leaves borne by the rachis of a large specimen. In the almost perfect specimen 190 mm. in length however I counted 46 mature leaves and 120 immature leaves on one side of the rachis. In some of the larger but imperfect specimens the number of immature leaves is over 250.

The autozooids composing a mature leaf are so crowded together that in the preserved

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specimens they cause a characteristic S-shaped bend in the leaf. I believe however that this bend is entirely due to contraction and would not be seen in the normal living colony.

The number of autozooids in the mature leaves has been counted in several specimens by myself and my pupils and we find an extraordinary variation. The numbers vary from 35—55.

KÖLLIKER gives 40—44 as the number of autozooids in each leaf, KÜKENTHAL and BROCH over 50 and, it is quite possible, numbers of 60—65 (*V. fusca*) or even 70 may occur with in the range of the species as in THOMSON and CRANE's (1909 p. 134) specimen from the gulf of Cutch.

The length of the autozooids from the top of the calices to the point where they join the rachis also varies considerably. In the largest leaves of a *Halisceptrum*-like specimen this measurement is 5 mm. but the average width of the mature leaves is about 3 mm. This measurement is of some value because the width of the widest leaves is a character which distinguishes this species from *V. juncea* where it is rarely more then 1.5 mm. and from *V. Gustaviana* (p. 175) where it is as much as 14 mm.

The immature leaves are gradually reduced in width and in expansion in passing from the region of the mature leaves towards the stalk. Approaching the stalk they are represented, as in other species of the genus, by a number of closely packed shallow ridges with only faint indications of the individual autozooids of which they are composed. Before the rachis joins the stalk the number of autozooids in each leaf is reduced and these very narrow leaves gradually sink into a groove and disappear. If we construct an isosceles triangle with the base 20 mm. from the point of disappearance of the leaves (textfig. 33 p. 162) it will be found that the average width of the leaf at the base is 2 mm. (c. f. *V. juncea* p. 163).

The siphonozooids. On the area (about 2 mm. wide) between the leaves, in the middle region of the rachis a large number of siphonozooids may be seen and, when stained horizontal sections of this area are examined with the microscope, it is seen that there are 3, 2 or 1 siphonozooids arranged between vertical parallel lines corresponding with each autozooid of the leaf above. The number of siphonozooids to each autozooid seems to vary arbitrarily (textfig. 34 p. 163). It does not increase or diminish towards the ventral or dorsal edges of the leaves, but it gives an appearance that suggests an arrangement in two or three horizontal or transverse rows ("ein- bis dreireihigen Gürteln", KÜKENTHAL). Such transverse rows are always quite irregular and do not correspond with any subjacent structures. It is more accurate to describe the siphonozooids as arranged in vertical rather than in transverse rows.

As it seemed to me an important point for the determination of the species I have made preparations from six specimens from Menado and from the specimens from Molo strait and Kwandang bay.

In all of them the arrangement of these siphonozooids is the same and in marked contrast to the arrangement of the siphonozooids of *V. juncea*. In addition to these siphonozooids there are others that appear to be scattered more irregularly on the dorsal track. I have altogether failed to find these "dorsal track" siphonozooids by examination of the surface with a magnifying glass and they are not easy to find even in stained horizontal sections.

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In thin transverse sections however they can be clearly seen and as shown above (Textfig. 32 p. 151) they have quite different relations to the ordinary siphonozooids between the leaves.

The axis. The axis in all the specimens I have examined, except those from Obi (vide infra) is cylindrical. It becomes very much attenuated and very flexible at the proximal end where it is usually, in the preserved specimens, bent into a hook projecting beyond the fleshy bulb by a tense membranous septum. At the distal end the axis is truncated and frequently projects beyond the soft parts for a distance of 10—20 mm. In one specimen three or four specimens of the barnacle *Dichelaspis orthogonia* are attached to this free end of the axis.

As a thorough examination of the whole axis involves a destruction of the specimen, and as it is improbable that this structure will yield characters of specific importance, I have not ascertained that the axis is consistently cylindrical throughout its whole length in all specimens. I will only add that in the region of the mature leaves of four specimens the axis was 2 mm. in diameter, that is to say measurably thicker than it is in *Virgularia juncea* in the same region.

When the axis is cleaned and examined with the microscope by reflected light it is seen to be marked superficially by a number of small sharp-edged, longitudinal striated ridges (Plate IX, fig. 62). A similar arrangement is seen in *V. gracillima* and *V. Roulei* but it is in striking contrast to that of *V. juncea* (Plate IX, fig. 63).

Spicules. Although KÖLLIKER states that in this species there are spicules in the stalk 10—23 μ in diameter I have failed to find them in any specimen examined.

6. *Virgularia Rumphii*? Kölliker.

Stat. 142. Off Obi. 23 metres. 8 fragments.

The eight fragments of a species of Virgularia collected at Obi, about 2 degrees of latitude North of Amboyna present some features of interest.

The general form of the leaves and the number of autozooids in each leaf (35) suggest at first sight that the fragments belong to the species *V. Rumphii*, but the siphonozooids are arranged in a single horizontal row and the axis is not circular in section but quadrilateral with very rounded angles, as in *V. ornata* of THOMSON and SIMPSON.

As regards the arrangement of the siphonozooids it may be noted that KÖLLIKER, in his original description of the species gives only a single horizontal row of siphonozooids and although in this respect the specimen differs from KÜKENTHAL and BROCH's description of the species and from all the specimens that I have examined from Menado, it is possible that the specimen should be regarded only as a variety.

Moreover KÜKENTHAL and BROCH describe the axis of *V. Rumphii* as "im Querschnitt rundlich eckig bis elliptisch" although in all the specimens I have examined, with this exception, it is perfectly circular in section.

The largest fragment is 77 mm. in length and 3 mm. in breadth but this and all the other fragments show well marked indications of exceptional contraction at or before death. It may be that this contraction accounts for two other features in which the specimen appears to be exceptional, namely, the shortness of the autozooids as compared with that of the more typical

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specimens and the presence of eight well marked grooves on their free extremities arranged like a star. The fragments consist of pieces of the rachis only, the stalk is entirely absent.

The texture of the axis is the same as that of *Virgularia Rumphii*.

Virgularia sp.?

Stat. 51. Molo Strait. 69—91 metres. 5 Ex.
Stat. 77. 3°27′ S., 117°36′ E. Borneo-bank. 59 metres. 1 Ex.

There are in the collection some small specimens and pieces of Virgularia that I have found very difficult to assign to any species. I think they are all young forms and until there is a larger series to hand it must remain doubtful whether they are young stages of known species or representatives of a new type.

In the collection from Stat. 51 there are five specimens and a bare axis. The largest specimen is 68 mm. in length with a maximum diameter of 2 mm.

The leaves of this specimen are composed of 6—8 autozooids and a special feature of the specimens is that many of these autozooids exhibit 8 distinct tooth-like tubercles on the calices as in *Virgularia cladiscus*.

The general form of the expanded autozooids is like that of the autozooids of *V. rubra* and the relation with that species is confirmed by the structure of the axis. On the other hand the axis is not coloured.

The siphonozooids are arranged usually in a single row at the base of each leaf and are approximately equal in number to the autozooids, but in one or two places the siphonozooids are in two rows.

The specimen from the Borneo bank is 80 mm. in length and has the colour of a small *Virgularia rubra* but in the middle of the rachis the siphonozooids appear in 2 or more rows instead of in a single row.

A young *Virgularia*.

Stat. 294. 10°12′ S., 124°27′ E. Off Timor. 73 metres. 1 Ex.

This little specimen, 34 mm. in total length, is of considerable interest as it appears to be undoubtedly a young form of Virgularia but differs in some respects from the young forms described by JUNGERSEN (1904) and from the *Protocaulon* of KÖLLIKER (1880 p. 26) which according to JUNGERSEN is also a young *Virgularia*.

The specimen exhibits three characteristic features of the genus *Virgularia*, namely the absence of spicules, the truncated axis and the position of the gonads in the region below the last fully formed leaf.

It resembles the specimens of young *Virgularia mirabilis* of 40 mm. in length described by JUNGERSEN (1904 p. 28) in having two autozooids to each leaf and undoubtedly has some resemblance to the *Deutocaulon histricis* of MARSHALL and FOWLER (1887 p. 461) in which there are three autozooids in each leaf.

JUNGERSEN suggests that MARSHALL and FOWLER's genus *Deutocaulon* is probably a young

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stage of *Virgularia mirabilis* or of *V. cladiscus* and as it seems very probable that his view is the correct one, we may call this Siboga specimen the "Deutocaulon" stage of a Virgularia.

The specimen is smaller than any of the young specimens of *Virgularia gracillima* from Stat. 321, but on comparing it with a specimen from that station that is 45 mm. in length some noteworthy differences can be observed which suggest that it is a deutocaulon stage of another species of *Virgularia*.

The principal points of difference between this specimen and the other young specimens of *Virgularia* that have been described as well as the young specimens from Station 321 are (1) that the leaves are relatively large although composed of only two autozooids, (2) that the larger mature leaves arise from one side of the rachis only (3) that the rows of immature leaves at the base of the rachis are invisible on surface examination and (4) that there are well developed male gonads in the region of the rachis where we should expect to find the immature leaves.

As it is quite impossible to determine without the study of series of sections the scientific boundary between the rachis and stalk in this specimen, it can only be said that the lowest visible autozooid on the rachis is at a distance of 13 mm. from the distal extremity.

The maximum width of the rachis is 0.14 mm. and of the stalk 0.36 mm. There is no definite basal swelling in the stalk but the end is ruptured and the axis protrudes.

6. *Virgularia Gustaviana* Herklots.

Halisceptrum gustavianum Herklots 1863. Polypiers nageurs. p. 31.
Halisceptrum gustavianum Kölliker 1872. "Die Pennatuliden". p. 172, Pls XI & XII.
Halisceptrum magnifolium Roule 1908. Alcyonaires d'Amboine. pl. 84.
Virgularia gustaviana Balss 1910. Japanische Pennatuliden. p. 46.
Virgularia gustaviana Kükenthal & Broch 1911. "Valdivia" Pennatulacea, p. 334.

Stat. 231. Amboyna, reef collection. 3 Ex.

This species, the type of the old genus *Halisceptrum* was rightly referred to the genus *Virgularia* by BALSS. It is represented in the collection by three specimens from the Amboyna reefs.

They are 404, 322 and 297 mm. respectively in length. The longest one has a damaged orange coloured stalk, the others are perfect at both ends and colourless.

The specimen 322 mm. in length has a stalk 80 mm. in length. The rachis including the leaves in situ is 22 mm. in width, the membranous bulb at the end of the stalk 12 mm. long and 13 mm. in diameter.

The leaves are 14 mm. in height at the dorsal edge and 25 mm. in length when measured along the outer border. Each of the larger leaves is composed of about 200 autozooids.

The siphonozooids are found in immense numbers between the leaves. I cannot express this accurately in figures but I have counted irregular rows of 10 or 12 between the base of one autozooid and the base of the corresponding autozooid of the next leaf. This may signify that there are nearly 2000 siphonozooids on each side of the rachis between every two succeeding leaves.

The siphonozooids seem also to spread over the whole of the dorsal track.

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The axis is quadrangular in section with very rounded angles and shows the same striated surface ridges as *V. Rumphii*.

There are many oval, round or irregular corpuscles in the membranous bulb of the stalk. The largest of these are .02 × .015 mm. but the greater number do not exceed .01 mm. in diameter.

The three specimens in the collection all clearly belong to KÖLLIKER's "Varietas magnifolia" of the species. ROULE was of opinion that this variety should be separated from the "Varietas parvifolia" as a distinct species to which he gave the name *Halisceptrum magnifolium*. Subsequent analysis by BALSS and by KÜKENTHAL and BROCH has not supported ROULE's view. The only three specimens in the collection are of approximately the same size and do not afford material for a reconsideration of the question. The specimens however clearly belong to the same species as those described by ROULE from the same locality.

A point of special interest in this species is the line or groove that extends from the last and youngest visible leaf for a distance of 25—30 mm. on to the stalk. This is known in the literature as the "Zooidstreif" and was first described by KÖLLIKER.

He regarded the part of the pen which bears it as rachis ("Kiel"). In the measurements given above I have reckoned it as stalk, as in the other species of *Virgularia*. KÖLLIKER (1872 p. 148) says "Den unteren Theil rechne ich aus dem Grunde zum Kiele, weil er zu beiden Seiten als Fortsetzung der untersten kleinsten Blätter einen schmalen ein- bis zweireihigen Streifen von Zooiden besitzt, welche den lateralen Zooiden beigezählt werden können".

It is true that when the bottom of this groove is examined with a hand lens a row of spots can be seen which have an appearance such as a row of siphonozooids would give. But is there any evidence that these spots are true siphonozooids? KÖLLIKER himself was not certain of it for he says on p. 151 "Als Fortsetzung dieser Zooide erscheinen von da an, wo die Blätter aufhören, die oben schon erwähnten Zooidstreifen von deren Elementen ich jedoch nicht mit Bestimmtheit behaupten kann dass sie dieselbe Bedeutung haben wie die lateralen Zooide".

I have made series of sections through the region and have failed to find any siphonozooids. There are folds of epithelium that may represent the beginnings of leaves or of siphonozooids but not a single example of a true and undoubted siphonozooid.

This line (the Zooidstreif) is much more pronounced than it is in any of the other species I have examined. It is, in all probability, morphologically a part of the rachis; but if in dealing with the systematics of the genus a region is regarded as rachis which does not show clear evidence in microscopic sections of either autozooids or siphonozooids the terms rachis and stalk cease to have any defined meaning and the measurements of the stalk to rachis ratio becomes valueless. It may be an artificial distinction, but unless we take the point where the zooids stop to be the boundary mark between rachis and stalk there is no guide to the measurements.

Virgularia Gustaviana is an extremely interesting species from many points of view. The large and well developed leaves, the numerous siphonozooids and the fleshy rachis seem to separate it from other species of the genus. In these respects it resembles so closely some

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of the species of *Pennatula* that it was separated from *Virgularia* by KÖLLIKER as a distinct genus *Halisceptrum* and placed in the sub-family Pennatulinae. The entire absence of spicules in the rachis, the presence of gonads only in the immature leaves and the dorsal radial canals are some of the characters which point undoubtedly to the conclusion that BALSS (1910) was perfectly right in assigning it to the genus *Virgularia*. The presence of a *Halisceptrum*-like specimen of *Virgularia Rumphii* in the collection from Menado emphasises this point.

The species has been previously recorded from Amboyna (KÖLLIKER 1872 p. 174) but has a wide distribution in the Indian Ocean, Malay Archipelago and China seas, in depths from shallow water to 150 metres.

Family PENNATULIDAE.

The family which includes as its type genus the true sea-pen or *Pennatula* is much more restricted now than it was in former times. KÖLLIKER (1872) divided his family Penniformes into two sub-families the Pteroidinae and the Pennatulinae but in 1880 he raised the sub-family Pennatulinae to the dignity of a family — the Pennatulidae — and included in it the four genera: *Pennatula*, *Leioptilum*, *Ptilosarcus* and *Halisceptrum*.

BALSS (1910) has shown that *Halisceptrum* is a true *Virgularia* and the species therefore has been transferred to the family Virgulariidae (see p. 175), and the difficult and little known genus *Ptilosarcus* of GRAY has been merged with *Leioptilum* by KÜKENTHAL and BROCH (1911) (see p. 188). On the other hand, I propose to transfer two genera from the Virgulariidae to the Pennatulidae and the family will therefore consist of the following four genera.

Pennatula Herklots
Leioptilum Gray
Acanthoptilum Kölliker
Scytalium Herklots.

The distinction between the two genera *Pennatula* and *Leioptilum* is very difficult to define as *Pennatula fimbriata* forms an almost complete connecting link between them.

According to the system of KÜKENTHAL and BROCH (1911 p. 155) the genera are distinguished by the following characters: —

1. Spicula gleichmässig über das ganze Blatt verteilt. Polypenkelch symmetrisch entwickelt . . . . . *Pennatula*
2. Spicula der Blätter fast ausschliesslich in den schief entwickelten Polypenkelchen . . . . . *Leioptilum*.

It is true that in most of the species of *Pennatula* the spicules are evenly distributed in the leaves but in the Siboga specimens of *P. fimbriata* they are only present on the margin of the leaves, the inner or lower two thirds of the leaves being quite free from spicules. In the specimens of this species from the Kei islands the spicules are almost entirely confined to the calices of the autozooids, in those from Timor the spicules extend further down on the substance of the leaf itself. We have therefore in the specimens from these localities two

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stages, as it were, in the restriction of the spicules to the margins of the leaves leading up to the condition that is typical for the genus *Leioptilum*.

A second distinction, but one which, as these authors quite rightly maintain, cannot be regarded as an important distinction, is that in *Leioptilum* there is only one (*L. sinuosus*) or two (*L. Gurneyi*) calyx teeth whereas in *P. fimbriata* and other species of the genus *Pennatula* there are usually four or eight.

In the type specimen of *Leioptilum (Ptilosarcus) sinuosum* in the British Museum I could find no evidence of calyx teeth at all, and in the figure given by KÜKENTHAL and BROCH (1911 p. 389) it is clear that the calyx teeth of *L. Gurneyi* are very short and broad.

There is a difference therefore between the genus *Leioptilum* and *Pennatula fimbriata* (the only species of Pennatula with which there can possibly be any confusion) as regards the armature of the margin of the leaves, for whereas in *Leioptilum* the margin of the leaves appears to be almost smooth, in *P. fimbriata* it has a setose appearance due to the projecting spicules of the calyx teeth.

Another distinction mentioned by KÜKENTHAL and BROCH is that whereas in *Pennatula fimbriata* the spicules which support the siphonozooids have a definite fan-shaped arrangement, in *Leioptilum* the siphonozooids have a more conical shape. I do not think this is a difference that can be relied upon, as in the Siboga specimens of *P. fimbriata* from the Kei islands there are no spicules supporting the siphonozooids and these zooids are indicated by small conical warts, whereas in the specimens from Timor we find the typical fan-shaped arrangement of the spicules.

A more important distinction than any of these appears to me to lie in the shape and constitution of the leaves. In the diagnosis of the genus *Leioptilum* given by KÖLLIKER (1872 pl. 39), he describes the leaves as kidney-shaped and KÜKENTHAL and BROCH (1911 p. 388) also describe the leaves of *L. Gurneyi* as "gross und nierenförmig". This description of the leaves answers very well for those of the type specimens of the genus in the British Museum which are in marked contrast to the triangular, fan-shaped or sickle-shaped leaves of *Pennatula fimbriata* and of nearly all the other species of that genus.

The leaves of *Leioptilum* are not only different in shape from those of *Pennatula fimbriata* but they are also decidedly larger and more closely set, so that the rachis as a whole has a much more compact form, as it has in *Sarcophyllum*. The only species of Pennatula in which we find anything approaching this compact form are *P. grandis* and *P. bellissima*.

It will probably be found, moreover, that in *Leioptilum* the leaves are composed of a great many more autozooids than in *Pennatula* but upon this point our knowledge of the species of *Leioptilum* is not sufficiently exact to enable us to make a definite statement.

In *Pennatula fimbriata* the number of autozooids composing the leaves appears to vary from 24—30. KÖLLIKER (1880 p. 8) gives the number as 24—26 in his description of the Challenger specimen which he named *P. sulcata*. BALSS (1910 p. 55) who examined a large number of specimens from Japan says that they agree with KÖLLIKER's description of *P. sulcata*. KÜKENTHAL and BROCH (1911 p. 377) give the numbers 25—26 and 26—28 for the two

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specimens they examined [1]), and in the Siboga specimens the autozooids varied from 25—30, in the larger leaves.

It is clear from these figures that in *Pennatula fimbriata* as in other species of the genus Pennatula the number of autozooids composing a leaf is not a large one.

The autozooids in the leaves of *Pennatula fimbriata* moreover are essentially arranged in a single row as BALSS (1910 p. 55) has pointed out: "Die Polypen auf den Blättern selbst stehen in Wirklichkeit einreihig; da sie aber nach beiden Seiten hin alternieren wird der Anschein mehrerer Reihen vorgetäuscht".

Turning now to the leaves of *Leioptilum*, we find in the literature no statement of the number of autozooids, but an examination of the figures given by GRAY (1860) and KÖLLIKER (1872 fig. 77) or of the original specimens in the British Museum, proves that the number is very much greater than in any specimen of *Pennatula*. They are very small and difficult to count but there must be over 100 even in the smaller specimens.

Moreover in all the descriptions of the genus the autozooids are said to be arranged in 2, 4 or many rows.

I have given some space to a discussion of the difference between *Leioptilum* and *Pennatula* in order to justify my action in retaining the former genus but there can be no doubt that these two genera are very closely related.

The inclusion of the genus *Scytalium* in the family Pennatulidae is proposed here for the first time. Hitherto *Scytalium* has found a place either in the family Virgulariidae or in the family Pavonariidae but it is difficult to say upon what grounds, other than the elongated shape which characterises most of its species.

The discovery of *Scytalium splendens* (Thomson and Henderson) (1906 (2)) has provided us with an example of a species that is not long and slender like a Virgularia but of more robust habit like a Pennatula. In my opinion these authors were quite right in placing their new species in the family Pennatulidae although they committed an error of judgment in placing it in the genus *Pennatula.*

Scytalium agrees with the other Pennatulidae in having well developed leaves, that is to say leaves composed of a single row of autozooids united together for the greater part of their length, in having the sexual organs developed in the larger leaves, in having the siphonozooids between the leaves and extending on to the dorsal track and in the absence of radial canals.

The principal difference between *Scytalium* and the other Pennatulids is that its spicules are always small, oblong or oval plates not exceeding .05 mm. in length, and never the long 3-flanged needles so characteristic of *Pennatula*.

If it be argued that this character of the spicules should separate *Scytalium* from the Pennatulidae it may be said that it separates the genus also from the Virgulariidae and the Pavonariidae.

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1) The statement made by KÜKENTHAL and BROCH (p. 376) in the diagnosis of the species that the autozooids are arranged in two to many rows and are up to 100 in number appears to be quite erroneous.

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The only alternative to the proposal I have made is to constitute a new family for the genus, an alternative which in my opinion is unnecessary and undesirable.

The genus *Acanthoptilum* has in the past usually followed the fate of *Scytalium* but as I have had no opportunity of examining any specimens of the genus, my opinion is based solely on the recent descriptions that have been published.

Like Scytalium, *Acanthoptilum* appears to have well developed leaves composed of a single row of autozooids, sexual organs developed in the larger leaves, siphonozooids on the dorsal track and no radial canals. It differs from Scytalium in having a fan-shaped group of long spicules supporting the base of the leaves.

NUTTING (1909 p. 700) has described several species of this genus from the coast of California and states that the spicules are of "the ordinary pennatulid type". KÜKENTHAL (1913) who has reinvestigated these species has given some good figures of the spicules and a further account of their distribution in the colony. In the description of *A. scalpellifolium* (p. 248) he says "In der Polypenwand liegen in Gruppen angehäuft schlanke dreiflügelige Nadeln von ca 0.36 mm. Länge, ausserdem kommen kürzere abgeplattete in der Mitte eingeschnürte Spicula von 0.12 mm.—0.18 mm. Länge vor, die sich auch in der Tentakelachse finden; die Kielrinde ist dicht erfüllt mit kleinen ovalen spicula von nur ca 0.03 mm. Längsdurchmesser". We have therefore in this genus both the long ridged needle-shaped spicules of *Pennatula* and the small flat oval spicules of *Scytalium* and, as regards the spicular armature, *Acanthoptilum* is intermediate between the other two genera of the family.

With the inclusion of *Scytalium* and *Acanthoptilum*, an amended statement of the characters of the family becomes necessary.

The Pennatulidae are bilaterally symmetrical sea-pens with well developed leaves. The leaves are usually thin and composed of a single row of autozooids, with short, free calices. The siphonozooids occur on the dorsal track and usually between the leaves as well but never on the leaves. The leaves bear spicules. The gonads are developed in the fully formed leaves. There are no radial canals. A well developed axis is always present.

The four genera may be arranged as follows: —

A. With large 3-flanged spindle or needle-shaped spicules distributed in the leaves.
   1. Leaves triangular, fan-shaped or sickle-shaped and with long and prominent calyx teeth on the autozooids . . . . . *Pennatula.*
   2. Leaves kidney-shaped, calyx teeth (where present) short and broad. *Leioptilum.*

B. With large 3-flanged spicules forming a fan-shaped support at the base of the leaves and small (.03 mm.) flat spicules in the calices, tentacles and rachis . . . . . *Acanthoptilum.*

C. With small (.05 mm.) flat spicules in the leaves . . . . . *Scytalium.*

Geographical distribution. *Pennatula* is cosmopolitan in distribution and extends from very shallow to very deep water. Our knowledge of the geographical distribution of *Leioptilum* is uncertain but it certainly occurs off the coast of California in depths of 50—120 metres, in the Magellan straits and off the coasts of Australia and New Guinea.

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Scytalium has been found in the Red Sea, Indian Ocean, Malay Archipelago and Japanese waters in depths of 19—186 metres.

Acanthoptilum is known only from the Californian coast and the Florida reef extending from shallow water to depths of 529 metres.

Genus **Pennatula** Linnaeus.

Pennatula (ex parte) Linné 1758. System. Natur. p. 818.
Pennatula Herklots 1858. Polypiers nageurs. p. 15.
Pennatula Kükenthal and Broch 1911. "Valdivia" Pennatulacea. p. 348.

The history of this well known genus has been so recently revised by JUNGERSEN (1904), by BALSS (1910) and by KÜKENTHAL and BROCH that it is not necessary to contribute more than a few lines or to describe it in detail.

The separation of *Pteroeides* by HERKLOTS from the old Linnean genus, and the fusion with *Pennatula* by KÖLLIKER (1872) of GRAY's genera *Phosphorella* and *Ptilella* have been accepted by all recent writers.

The following list gives the names of the species that are recognised: —

P. aculeata Kor. and Dan.
P. bellissima Fowler.
P. fimbriata Herklots.
P. indica Thom. and Hend.
P. inflata Kükenthal.
P. grandis Ehrb.
P. prolifera Jung.
P. Moseleyi Köll.
P. Murrayi Köll.
P. Naresi Köll.
P. Pearceyi Köll.
P. pendula Thom. and Hend.
P. phosphorea Linn.
P. rubra Ellis.

Pennatula alata and *P. Köllikeri* from the W. central America seas have not yet been sufficiently well described by STUDER (1894 p. 55) to be recognisable. *Pennatula splendens* and *P. veneris* of THOMSON and HENDERSON (1906 (2) pp. 115, 116) are certainly species of the genus *Scytalium* (see p. 203).

NUTTING (1908 p. 557) has described three new species from the Hawaiian islands, *P. flava*, *P. pallida* and *P. sanguinea*.

The position of these three species is difficult to determine as the description is inadequate and the illustrations too indistinct to be of much use. They are all small specimens the largest being only 200 mm. in length and it is possible that they are only young forms of the other species, but a comparison of the types of these species with other species from the Pacific Ocean might justify their retention as distinct species.

The same author has also (1912 p. 32) proposed four new specific names for specimens obtained in Japanese waters, namely: — *P. brevipenna*, *P. inermis*, *P. longistyla*, *P. rubescens*.

The specimens named *P. inermis* have some resemblance to the species named *Pennatula splendens* by THOMSON and HENDERSON. Their resemblance to this species, their very minute oval or rod-like spicules and the figure which illustrates the text suggest very forcibly that they belong to the genus *Scytalium* and not to *Pennatula* at all.

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The *Pennatula rubescens* exhibits, among other characters, a group of 3 or 4 large siphonozooids opposite the base of each leaf and in this respect recalls a feature of *Pennatula Naresi*. It is possible, from the general description, that it is a young specimen of this species, a common one in Japanese waters.

Pennatula longistyla, founded on a single specimen from a depth of 128 metres is very much like a young *P. fimbriata*.

P. brevipenna, founded on a single specimen from a depth of 119 metres has a form of leaf similar to that of *P. Murrayi* and it also possesses the single large siphonozooid opposite the base of each leaf. It has not however the brilliant coloration that usually characterises specimens of that species.

Of recently described species, *P. sulcata* of KÖLLIKER (1880) has been shown to be identical with *P. fimbriata* (see p. 185). The suggestion made by BALSS (1910) that *Pennatula Pearceyi* is a young form of some well known species has been contested by KÜKENTHAL and BROCH who, by the study of a large number of specimens, have confirmed its position as a distinct species.

The species named *Pennatula borealis* by SARS afterwards referred to by KOREN and DANIELSSEN (1877 p. 83) as *Ptilella grandis* and of recent years (JUNGERSEN 1904 p. 16) included in the species *Pennatula grandis* of EHRENBERG exhibits large siphonozooids (mesozooids) on the dorso-lateral tracks similar to the mesozooids of *P. Murrayi*.

The mesozooids in this species however are not arranged one opposite the dorsal edge of each leaf as they are in *P. Murrayi*.

On this point there are some noteworthy differences in the statements of previous authors. In the original description by SARS (1846 p. 17), after reference to the groove on the dorsal side of the rachis, he writes: "— auf den Seiten hinten zwischen den Finnen der Fahne ist er überall mit zahlreichen sehr kleinen bluthrothen Wärzchen, von denen die grössten sich deutlich als hohl mit einer in zwei Spitzen ausgerandeten Oeffnung am Ende zeigten, besetzt. Vielleicht tritt durch diese Oeffnungen das Meerwasser in den Polypenstamm hinein".

KÖLLIKER in describing *Pennatula borealis* (1872 p. 137) says: — "Besonders grosse Formen (i. e. of Siphonozooids) stehen, wie es scheint, je Eine zwischen zwei Blättern und zeigen deutlich eine von zwei Spitzen begrenzte Mündung, wie schon SARS meldet". KOREN and DANIELSSEN (1877 p. 83) on the other hand write "Of the lateral zooids some are especially remarkable for their size and are moreover usually situated two at each leaf base". I have examined two large specimens of this species from 180 fathoms off the Faeroe islands presented to the Manchester Museum by Professor JUNGERSEN. In these specimens the mesozooids are very conspicuous and with their bidentate verrucae and wide open mouths are very similar in external features to the mesozooids of *P. Murrayi*. They are however much more variable in number, as in each specimen groups of two, three or more rarely four may be seen close to the dorsal edge of the leaves. The specimens are not very well preserved for histological examination but the mesozooids show a large stomodaeum with a weak siphonoglyph and muscular bands on the mesenteries as in *P. Murrayi*.

Having had but little opportunity of studying the common species of the genus I have

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not found it possible to draw up a definite key plan but the following remarks on the recognised species may be of use to systematists.

P. fimbriata is a very distinct species with leaves composed of small autozooids. The spicules are small and usually confined to the calices and to the edges of the leaves. The siphonozooids on the dorsal track are very numerous.

In the remaining species the spicules are larger and distributed throughout the whole width of the leaf. In *P. inflata* (KÜKENTHAL and BROCH 1911 p. 350) from 625—741 metres off the Somaliland Coast, the siphonozooids of the dorsal track are arranged in curious kidney shaped pads bending round the dorsal edges of the leaves.

P. phosphorea, *P. aculeata*, *P. rubra* and *P. indica* form a group in which the siphonozooids are very numerous on the dorsal track leaving only a very narrow track in the middle line free from them

Of these *P. rubra* according to the account of the species given by KÜKENTHAL and BROCH (1911 p. 383) has a single large zooid close to the dorsal edge of each leaf which will probably prove to be a mesozooid.

P. aculeata has a group of large zooids in this position which may prove to be mesozooids but are in any case larger than the ordinary siphonozooids.

P. phosphorea and *P. indica* have siphonozooids on the dorsal track which are all of the same size and there are no mesozooids. *P. indica* from 847—1507 metres in the Indian Ocean and from 2798 metres in the Malay Archipelago may be only a deep sea variety of *P. phosphorea* and the same way be said of the remarkable *P. prolifera* described by JUNGERSEN (1904 p. 15) from 2120—2624 metres in the Atlantic Ocean.

P. Naresi, *P. Moseleyi*, *P. Murrayi*, *P. Pearceyi* and *P. grandis* form a group in which there is a broad space in the middle of the dorsal track free from siphonozooids. Of these *P. Murrayi* and *P. grandis* certainly possess mesozooids. *P. Murrayi* has only one mesozooid close to the edge of each leaf, *P. grandis* one or more mesozooids in that position.

P. Naresi has a group of large zooids close to the edge of each leaf but it is not known whether these are siphonozooids or not. The species however is characterised by its very thick stalk and thick brittle leaves. An examination of the type specimens of *P. Moseleyi* leads me to believe that it is only a young specimen of *P. Naresi*, and *P. Pearceyi* is also related to this species but is regarded by KÜKENTHAL and BROCH (1911 p. 361) as a distinct species. It agrees with *P. Naresi* in having spicules in the tentacles of the autozooids but it has a much more slender stalk.

P. bellissima, from off the Bahamas (FOWLER 1888 p. 135) and recently described by STEPHENS (1909 p. 17) from 975—1042 metres off the Irish coast, has numerous siphonozooids on the dorsal track but the description does not make it clear whether it belongs to the last named group or to the former.

STEPHENS regarded it as related to *P. grandis* and it certainly resembles that species in its large leaves but there is no evidence that it possesses mesozooids.

There is no sufficiently detailed account of *P. pendula* from 435—530 metres in the Indian Ocean to enable me to place it any of these categories but it seems to be a good species.

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1. *Pennatula fimbriata* Herklots. (Textfig. 36).

Pennatula fimbriata Herklots 1858. Polypiers nageurs. Pl. III & IV.
Leioptilus fimbriata Gray 1860. Ann. N. H., V, p. 22.
Pennatula sulcata Kölliker 1880. "Challenger". Pennatulida. Pl. II.
Pennatula fimbriata Balss 1910. Japanische Pennatuliden. p. 55, Pls I, IV.
Pennatula fimbriata Kükenthal & Broch 1911. "Valdivia" Pennatulacea. p. 376.

Stat. 251. 5°28′ S., 132°0′ E. Kei Island. 204 metres. 1 Ex.
Stat. 256. 5°26′ S., 132°32′ E. Kei Islands. 397 metres. 1 Ex.
Stat. 289. 9°0′ S., 126°24′ E. S. coast of Timor. 112 metres. 3 Ex.

When these specimens were first examined I thought they were identical with Gray's species *Ptilosarcus sinuosus* and the specimens were referred to as such in a paper written by my pupil Miss Winifred Coward (1909) on the interesting new Gymnoblastic Hydroid *Ptilocodium repens* which was found epizoic on its leaves.

There can be no doubt that all the five specimens are identical with Kölliker's species *Pennatula sulcata* from the Philippine islands 18—37 metres (Kölliker 1880 p. 8) and Balss appears to be quite justified by his researches in regarding Kölliker's species as a synonym of Herklots' *Pennatula fimbriata*.

They differ from the description of *Pennatula sulcata* given by Kölliker in two respects, 1. The area on the dorsal track that is free from siphonozooids is much narrower and 2. the long row of siphonozooids on the ventral edges of the leaves is absent.

The principal measurements are: —

	Station 289.			Station 251.	Station 256.
Total length	168 mm.	100 mm.	86 mm.	122 mm.	79 mm.
Length of rachis	108 „	90 „	56 „	70 „	49 „
Length of stalk.	60 „	30 „	30 „	52 „	30 „
Width of the rachis	38 „	16 „	17 „	40 „	30 „
Number of leaves	30 R.	25 R.	20 R.	28 L., 29 R.	20 L., 21 R.
Length of dorsal margin of leaf	18 mm.	7 mm.	12 mm.	15—17 mm.	11 mm.

The two specimens from the Kei islands differ from the three specimens from the S. coast of Timor in several important respects and it is necessary therefore to describe them separately.

Specimens from S. coast of Timor (Stat. 289).

The general form and substance of these specimens is very similar to that described and figured by Kölliker for his species *P. sulcata*, but not so stout as the figures given of the type specimens by Herklots.

In these specimens the characteristic groove on the ventral side of the rachis may be very easily overlooked as the lips are fused together for the greater part of their length in the largest and in the smallest specimen, and for their whole length in the middle specimen.

Balss (1910), who had the advantage of examining a large number of specimens of this species from Sagami bay, calls attention to the many variations that this groove presents and states that only in one specimen were the lips fused together for their whole length.

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The smooth surface of the groove, its variability and the fusion of the lips in some specimens and not in others call to mind the grooved or channelled stem of the Alcyonacean genus *Solenocaulon*.

I have suggested in a previous paper that this feature of *Solenocaulon* is the result of a Crustacean epizoite. This view was vigorously opposed by JANOWER (1904) but supported later by KINOSHITA (1913).

It seemed to me probable that the ventral groove and channel in *Pennatula fimbriata* was of the same nature and this view was supported by the variability in its development described by BALSS.

In order to search for the supposed epizoite the canal of one specimen was cut open from end to end but nothing was found in it; but on examining the smaller specimen from Stat. 289 the head, with protruded gizzard, of a polychaet worm was seen projecting from an opening of the canal at a distance of about 20 mm. from the distal end. The setae of the worm could be seen through the semi-transparent tissues of the ventral side of the pennatulid and there can be little doubt that the body of the worm lies in the canal.

No further dissection of the specimen was made and therefore the genus of the worm was not determined; but the specimen remains intact, with the worm in position as it was when it reached me, for further study by any one interested in this remarkable case of symbiosis.

The discovery of this worm is of interest for two reasons; it proves that the groove, or canal that occurs in this species is due to the activity of an epizoite, as I believe the canal of *Solenocaulon* is also due to an epizoite, and it confirms the view expressed by BALSS that *Pennatula fimbriata* and *Pennatula sulcata* are identical.

It offers however no explanation of the remarkable fact that, whereas most of the Pennatulids are free from epizoic growths of all kinds, in these specimens there is not only the epizoic polychaete worm but also numerous colonies of the hydroid *Ptilocodium*.

The leaves vary in number with the length of the rachis and in shape with their position. The younger leaves at the base are long narrow and pointed (lanceolate) but the mature leaves in the upper and middle region are sickle to fan-shaped. In all cases the leaves are thin and in the preserved specimens many of them are folded and crumpled. They are composed of a single row of autozooids, 25—30 in number, but difficult to count accurately in any one case because they are so broken. The anthocodiae are withdrawn in most cases and the calices are supported by a number of long projecting spicules varying in length but with a maximum of about 0.85 mm. In a few cases the spicules project from the calices as 4 tooth-like processes but these processes are so frequently bent or broken that I cannot hazard the statement that a four-toothed calyx is a normal condition. These spicules of the calyx are supplemented by other spicules more irregularly arranged on the margin of the leaf and a few scattered spicules extending for a distance of a millimetre or two from the margin. The spicules at the margin of the leaf are much more numerous and extend further down in the specimens from Timor than in the specimens from the Kei islands. In both sets of specimens there are no spicules at all in the lower $^{2}/_{3}^{rds}$ of the leaves.

A very noteworthy feature of the margin of the leaves of all the Timor specimens is

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the presence of the remarkable Gymnoblast *Ptilocodium repens*. (COWARD 1909). It is the only recorded case of any sedentary epizoite on the living tissues of a Pennatulid. Barnacles occur sometimes on the exposed axis of *Virgularia*, Porcellanella crabs more frequently between the leaves of *Pteroeides* and there are some cases of Ophiurids with their arms entwined round the stems and leaves of other genera but there are no other cases of an epizoite attached to the living polyps.

The siphonozooids are very numerous on the dorsal track and between the leaves. They even extend on to the ventral track. There is in the middle line of the dorsal track a narrow space free from siphonozooids and this is usually depressed in the preserved material as a groove.

This dorsal groove however is clearly of a different nature to the ventral groove mentioned above and it is very probable that it is only a postmortem structure.

There are numerous spicules in the dorsal track and the siphonozooids are supported by an arrangement of these spicules which is either fan-shaped or bidentate. The arrangement of these spicules is very much like that drawn by KÜKENTHAL and BROCH in their text fig. 174 p. 377. These spicules are not present in the specimens from the Kei islands.

The stalk does not present any point of special interest. In all the specimens it appears to have been cylindrical in shape with a slight swelling above, where it joins the rachis, and a conically pointed base. In the largest specimen the diameter of the swelling is 7 mm. and of the stalk below the swelling 4.5 mm. and in the other two these diameters are 6 mm. and 3.75 mm., and 2 mm. and 1.5 mm. respectively.

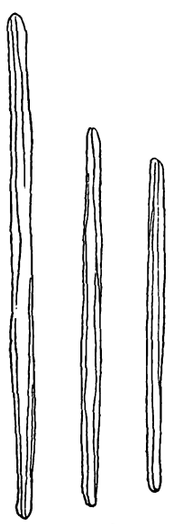

Fig. 36.
Spicules of the leaves of *Pennatula fimbriata* from Station 251. × 70 diam.

There are three types of spicules in all the specimens; namely those of the leaf, those of the dorsal track and those of the cortical layers of the stalk.

The leaf spicules are long rods with the characteristic ridges of the genus. They show considerable variation in the details of their structure but usually they are a little wider in the middle than they are near the ends and the extremities are slightly expanded, rounded off or knobbed. A typical spicule that I measured was 0.7 mm. in length 0.1 mm. in diameter in the middle, 0.08 mm. in diameter at a short distance from the extremities and 0.1 mm. at the extremities.

The longest spicules measured in the Timor specimens were 0.9 mm. in length. Others were 0.8, 0.6 and 0.3 mm. respectively.

The spicules of the dorsal track which form the curious clusters that support the siphonozooids are short rods, the larger ones being about 0.26 mm. in length × .017 mm. in diameter. They are distinctly 3-flanged.

The spicules of the stalk are flat, oval plates without ridges and are densely crowded. They vary a great deal in size and shape. The largest forms are 0.134 mm. in length and about .034 mm. in greatest width. Smaller ones are .1 × .03 mm. and .08 × .04 mm. The smallest ones that could be measured in the crowd were .05 mm. in length.

The axis is white and cylindrical.

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Specimens from Kei Islands.

The two specimens from Kei islands are decidedly wider across the rachis than those from Timor.

In both specimens there is a deep ventral groove but in neither are its lips fused to form a tube. In the specimen from Stat. 256 the lips are closely apposed all along the middle region of the rachis, but distally the groove becomes shallow and the lips are wide apart. On the dorsal side there is also a narrow groove similar to that in the other specimens extending upwards for a distance of about $^{2}/_{3}^{rds}$ of the total length from the lower end of the rachis.

The siphonozooids are very numerous but there is a narrow strip of the dorsal track that is free from them. In the middle of this track the siphonozooids appear to be continuous across the groove but this appearance may be due, in part to shrinkage during preservation.

The stalk of the specimen from Stat. 256 is similar to that of the specimens from Timor. At its junction with the stalk it is 3 mm. in diameter the swelling is 5 mm. in diameter and below the swelling it is 4 mm. in diameter. The stalk of the other specimen from this locality is damaged.

The spicules of the leaves are not so numerous as in the specimens from Timor nor do they extend beyond the anthocodiae but the most remarkable feature of these specimens perhaps is the absence of spicules in the dorsal track. It is not possible to assert positively that there are no spicules at all in this region but none were seen when searching over the track with a low power nor were they seen in the little samples that were cut out of both specimens and mounted for examination with a higher power.

The spicules in the cortical layers of the stalk are of the usual type but speaking generally, smaller and not nearly so numerous as in the other specimens. The leaf spicules vary from 1.0 × .06 mm. to .5 × .03 mm. The stalk spicules from .09 × .012 mm. to .05 × .017 mm. but in a preparation from the specimen from Stat. 251 a few of the stalk spicules attained a length of .1 mm.

The leaves of neither specimen bear *Ptilocodium*.

I do not think there can be any doubt that the specimens from the two localities belong to the same species. The structure and number of the leaves, the distribution of the siphonozooids, the size and shape of the spicules and other characters are so much alike that to separate them would be unreasonable. Nevertheless the difference in the size of the leaves and in the character of the ventral groove and the absence of spicules in the dorsal track in the Kei islands specimens are interesting and important divergences.

It will be noticed that the specimens from the Kei Islands came from deeper water but there is no evidence to show that the differences are correlated with depth.

There is undoubtedly a certain resemblance between *Pennatula fimbriata* and specimens that have been described under the name *Leioptilum sinuosum* and, as KÖLLIKER (1870 p. 368) has pointed out, *Leioptilum Grayi* is closely related to the genus *Pennatula*.

The genus *Leioptilum*, however, is, with two doubtful exceptions, confined to the waters of the West coast of America and *Pennatula fimbriata* has only been found in the Japanese and Malayan seas. The consideration of geographical consideration therefore confirms the view of those who hold that *Pennatula fimbriata* is distinct from the genus *Leioptilum*.

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But there is a considerable amount of interest arising from the two doubtful exceptions to which reference has been made above.

In GRAY's Catalogue of sea-pens, three species are described with the following names and localities: *Sarcoptilus grandis* Australia, *Ptilosarcus Gurneyi* California and *Ptilosarcus sinuosus* New Guinea.

One of the specimens in the British Museum, bearing the name *Sarcoptilus grandis* with the locality "Sydney", is undoubtedly, as KÖLLIKER (1870 p. 368) says, a *Leioptilum* and has been renamed *L. Grayi*. *Ptilosarcus Gurneyi* is also a *Leioptilum* but as the locality is "California" no special interest is attached to the specimen. *Ptilosarcus sinuosus* with the locality New Guinea, however is also a *Leioptilum* according to the view of KÜKENTHAL and BROCH (1911 p. 388).

I have carefully reexamined these three specimens and although I am of opinion that the *Ptilosarcus sinuosus* is a *Leioptilum* I am doubtful whether it should be regarded as synonymous with the *Leioptilum undulatum* of VERRILL.

We are indebted to KÜKENTHAL and BROCH (1911 p. 388) for a full description of six specimens of a *Leioptilum* from Panama and Pescadores which is probably the same as the *Leioptilum undulatum* of VERRILL.

The type specimen of *Ptilosarcus sinuosus* differs from this description in several particulars.

The calices do not show a tooth or teeth formed by converging spicules. The siphonozooids are not small but remarkably large and prominent scattered in great numbers over the whole of the dorsal track. There are no siphonozooids, visible with a hand lens, between the leaves. There is no swelling at the upper end of the stalk just below the rachis but there is a well marked basal bulb in which no spicules could be seen with a hand lens. In all these respectively it differs from the description of the Panama specimens of *Leioptilum*.

The specimen is badly bent at the top but I estimated that the total length is 110 mm., i. e. a little longer than the largest Panama specimen. The length of the rachis is 57 mm. and of the stalk 53 mm. The diameter of the rachis is 13 mm. of the upper cylindrical part of the stalk 11 mm. and of the basal bulb 16 mm. These measurements are not inconsistent with the view of KÜKENTHAL and BROCH that it is synonymous with *Leioptilum undulatum*, but the conclusion arrived at from structural characters is that it is probably not of the same species as the specimens from the West coast of Central America.

But if it is a *Leioptilum* the locality "New Guinea" is remarkable. It is possible that some error has been made but my inquiries have revealed no reason for doubting the accuracy of the original label on the bottle which contains the specimen.

As regards the specimen labelled *Sarcoptilus grandis*, loc. "Sydney" now called *Leioptilum Grayi*, some doubt may be expressed as to the accuracy of the label. The word "Sydney" is written after the words *Leioptilum Grayi* and has evidently been added at a later date than the words *Sarcoptilus grandis*. In the description of the specimen moreover KÖLLIKER says (1870 p. 368) "Nach Dr. GÜNTHER stammt dasselbe *wahrscheinlich* aus Australien".

The occurrence of the genus *Leioptilum* outside the area of the Eastern side of the Pacific Ocean has been definitely recorded, therefore, only in the case of the type specimen of *L. (Ptilosarcus) sinuosum*. The future alone can determine whether the accuracy of this locality

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will be confirmed or not. *Sarcoptilus grandis* of GRAY is certainly not a *Sarcophyllum* (cf. KÜKENTHAL & BROCH 1911 p. 441).

Whatever may be the true locality of this specimen it is not of the same species as the specimens here described under the name *Pennatula fimbriata*, and the specimen affords no support for an attempt to merge Leioptilum with Pennatula, or to transfer *Pennatula fimbriata* to the genus *Leioptilum* [1]).

2. *Pennatula Murrayi* Kölliker. (Plate III, fig. 16; Plate IX, figs 65—68.

Pennatula Murrayi Kölliker 1880. "Challenger" Pennatulida. p. 5, Pl. II.
Pennatula Murrayi Moroff 1902. Studien über Octocorallien. p. 383.
Pennatula Murrayi Hickson 1905. Maldives Alcyonaria. p. 823.
Pennatula Murrayi Balss 1910. Japanische Pennatuliden. p. 56.
Pennatula Murrayi Kükenthal and Broch 1911. "Valdivia" Pennatulacea. p. 358. Pl. XXII.

Stat. 167. 2° 35′ S., 131° 26′ E. Near Sabuda Island. 95 metres. 1 Ex. Juv.
Stat. 254. 5° 40′ S., 132° 26′ E. Kei Islands. 310 metres. 2 Ex.
Stat. 256. 5° 26′ S., 132° 32′ E. Kei Islands. 397 metres. 3 Ex.
Stat. 260. 5° 36′ S., 132° 55′ E. Kei Islands. 90 metres. 1 Ex. Juv.
Stat. 289. 9° 0′ S., 126° 24′ E. Coast of Timor. 112 metres. 7 Ex.

These specimens will be arranged for purposes of description into three groups A, B, C.

In group A are included the 7 specimens from the coast of Timor (1—7), in group B the four larger specimens from the Kei islands (8—11) and in group C, the two relatively small specimens (12—14) from the Kei islands and the specimen from Sabuda island.

It will be shown in the course of the description that the specimens from Timor differ in certain particulars from those from deep water off the Kei islands.

GROUP A.

N°.	1.	2.	3.	4.	5.	6.	7.
Total length in mm.	348	468	520	300	350	460	600
Length of rachis „ „	283	390	440	242	290	380	?
Length of stalk „ „	65	78	80	58	80	80	?
Number of autozooids in the larger leaves	14	15—20	15—20	14—15	13	15—19	16—20

GROUP B.

N°.	8.	9.	10.	11.
Total length in mm.	400	212	310	370
Length of rachis „ „	270	137	220	280
Length of stalk „ „	130	75	90	90
Number of autozooids in the larger leaves	12—13		10—12	10—12

GROUP C.

N°.	12.	13.	14.
Total length in mm.	90	108	74
Length of rachis „ „	50	88	49
Length of stalk „ „	40	20	25
Number of autozooids in the larger leaves	6	5—6	5

In group C N° 12 is from Station 256, N° 13 from Station 260, N° 14 from Station 167.

1) For further discussion of the relation of *Leioptilum* to *Pennatula* see p. 177.

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It will be observed from these figures that the specimens in Group A have a relatively shorter stalk than those in Group B, and that they have rather larger leaves composed of a greater number of autozooids.

As regards Group C, specimen 12 is clearly a young specimen of the Group B type. It was obtained at the same station and has a relatively long stalk. Specimen 13 has a relatively short stalk and has in this respect closer affinities with the type A. Specimen 14 has a stalk of intermediate length a great deal shorter than that of Specimen 12 but longer in proportion than that of Specimen 13.

The correlation between the stalk-rachis ratio and the depth in the Siboga specimens seems to be confirmed by comparison with specimens from other localities. Taking Group A of the "Siboga" specimens from a depth of 112 metres, showing a rachis 3.6 to 5.5 times the length of the stalk as a standard for shallow water forms, we find that the specimen described by BALSS (1910 p. 56) from 150—180 metres from Japan has a rachis 3.9 times the length of the stalk, a specimen from Suvadiva in the Maldive Archipelago (HICKSON, 1905, p. 823), depth 43 metres, has a rachis 5.4 times the length of the stalk, and a specimen from the Seychelles, not yet described, from 68 metres has also a very long rachis as compared with the stalk.

Taking Group B of the "Siboga" specimens from a depth of 310—397 metres, showing a rachis 2—4 times the length of the stalk as a standard for the deeper water forms, we find the specimen described by KÖLLIKER (1880 p. 5) from 236 metres off Ceram has a rachis 2.5 times the length of the stalk and the specimens described by KÜKENTHAL and BROCH from 296 metres in the Indian Ocean have a rachis 2—4 times the length of the stalk.

These facts all point to the conclusion that in *Pennatula Murrayi* the greater the depth the greater is the length of the stalk.

The number of leaves varies to some extent with the length of the rachis.

In specimen 5 of Group A there were about 71 on each side, of which 11 were rudimentary, in specimen 10, of Group B there were 65, of which 13 were rudimentary and in specimen 12 of Group C there were 18, of which 6 were rudimentary. These figures agree approximately with those given by KÜKENTHAL and BROCH for the specimens collected by the Valdivia expedition. There is some difficulty in determining the exact number of leaves on each side, as there is in all specimens a considerable number of very small or rudimentary leaves at the proximal end of the rachis and, without careful microscopic examination, it is impossible to be certain whether the last papilla visible with a magnifying glass is in reality the last representative of a leaf or not.

In the specimens belonging to Group B there are more rudimentary leaves in proportion to the total number of leaves but this is not a statement that can be put into figures without forming a quite arbitrary conception as to what is a rudimentary leaf and what is not.

The number of autozooids in a leaf varies with the length of the rachis, as seen in the table on p. 189, but there is also a difference between the two groups as regards this number, the leaves of Group A having appreciably more autozooids than those of group B.

In specimen 5 (Group A) the leaves situated at a distance of 118 mm. from the base of the rachis were 119 mm. in length and 7 mm. across at the base of insertion, at 156 mm.

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from the base they were 30 × 7 mm. and 230 mm. from the base they were 20 × 7 mm. The largest leaves of specimen 8 were only 13 × 4 mm.

The leaves of Group B moreover are much more richly provided with spicules than those of Group A and this accounts to some extent for the greater transparency of the leaves of the latter group.

The autozooids. In all the specimens the autozooids are arranged in a single row on the leaves and are provided with calices supported by eight groups of spicules which converge distally to form eight projecting spines. The individual autozooids are fused with their neighbours immediately below the neck of the calyx and in this respect the species differs from the closely related species *P. Pearceyi*, in which the distal free part of each autozooid is much longer.

Nearly all the anthocodiae are completely retracted in the specimens at my disposal but by dissection I have not been able to find spicules in the tentacles or body wall of any specimen. In this respect then they agree with the definition of the species given by KÜKENTHAL and BROCH (1911 p. 358) and differ from *P. Pearceyi*.

The siphonozooids are arranged in a single or double row between the leaves, there is a large mesozooid on the dorsal track close to the edge of each leaf and in some of the specimens there are groups of siphonozooids situated on the edge of the dorsal track extending between the mesozooids on each side of the rachis (Plate IX, fig. 66).

The mesozooids are very conspicuous objects in all the specimens. They project above the general surface of the rachis in the form of a rounded or conical verruca and are provided with a pair of transversely or obliquely disposed tooth-like points frequently distinguished by their bright colour. A more detailed description of these remarkable siphonozooids is given on p. 194.

The siphonozooids on the edge of the dorsal track are much smaller than the mesozooids but larger than the siphonozooids that lie between the leaves. They project from the surface of the rachis as small shallow cones. In the specimens of Group A they are far more numerous and conspicuous than in the specimens of Group B and in some of the specimens of the latter group the mesozooids are apparently the only zooids that extend on to the dorsal track at all.

In specimen 5 (Group A) there are, in the middle region of the rachis 12—15 siphonozooids on the edge of the dorsal track between every two mesozooids and 20—25 siphonozooids in two rows, situated laterally between the leaves.

In specimen 8 (Group B) there are only two or three siphonozooids on the edge of the dorsal track between the mesozooids and a single row of about 15 siphonozooids between the leaves.

Making a rough estimate, therefore, there are on an average 40 siphonozooids per leaf in specimen 5 and 20 siphonozooids per leaf in specimen 8.

The stalk in all the specimens shows an oval swelling just below the rachis (Plate III, fig. 16). In specimen 5 this swelling is about 20 mm. in length and 5 mm. in greatest diameter, below this swelling the stalk continues as a cylindrical rod to the proximal end where it terminates in a conical point. This upper stalk swelling is present in all the specimens but varies a good

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deal in size, the variation being due in all probability to the condition of contraction in which the specimen was killed.

The swelling is not so pronounced in the specimens from deep water but I do not regard this as a feature of any special importance.

The spicules of the rachis have the usual form of the spicules of the genus — long, 3-flanged needles or spindles —. They are loosely and irregularly scattered in the cortex of the dorsal track and leaves but more crowded and definitely arranged in the crown and points of the calices.

In specimen 5 the spicules of the points of the calyx are 0.3—0.6 mm. in length with a maximum breadth in the middle of about 0.08 mm. In specimen 8 the spicules of the same region are much larger, being in some cases 1 mm. in length.

There is evidently great variation in the length and in the arrangement of the spicules in these specimens but after examining a great many preparations it is quite certain that the spicules of the deep sea forms are larger than those of the shallow water forms.

KÖLLIKER (1880 p. 6) gives the size of the largest yellow spicules of the type specimen from a depth of 236 metres as 1.28 × 0.085 mm. and the largest red spicules 0.85 × 0.04 mm. This corresponds more closely with the measurements of our deep sea forms than with those of the shallow water forms.

As the spicules are nearly all coloured red or yellow their presence can usually be detected, when present, in the cortex of the rachis and stalk without microscopic investigation. In the specimens of Group A they are present in enormous numbers in the deeply coloured band at the upper end of the stalk swelling. Below this they disappear and in preparations of the white parts of the stalk only a few isolated spicules of small size, 0.1 mm. in length can be seen in the cortex.

The calcareous corpuscles of the inner parts of the stalk ("Stielinnern") appear to be very scarce and scattered. After making several preparations of specimen 5, I found one series of white oval corpuscles about 0.01 mm. in length situated at intervals of 0.06—0.1 mm. with in some cases a couple close together.

The colour of these specimens shows considerable variation. The specimens 1 to 4 have a rosy coloured rachis which becomes darker in colour and forms a band of darker red just above the swelling of the stalk. The stalk in all these specimens, below the band, is white or pale yellow.

The rosy colour of the rachis is by no means uniform. Some leaves being much darker in colour than others, some quite pale.

In one specimen the dorsal track is pale yellow. This yellowish tint is shown on the calices of some of the autozooids.

Specimen 6 has a yellow rachis ending in a band of red about 5 mm. in width just above the swelling of the stalk. Although the leaves are yellow the calices are pink and the large siphonozooids at the base of the leaves are also surrounded by a group of pink spicules (Plate III, fig. 16).

In specimen 7 the rachis is almost white but a band of red spicules above the swelling

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of the stalk is very pronounced. Some of the leaves are partly or wholly pink, others quite white.

Specimens from Stations 254 and 256 are not so strikingly coloured. The stalk and rachis are pale yellow, but there is no marked band of coloured spicules above the swelling of the stalk. The leaves are pink and in the specimen from Station 254, the calices are more pronounced in colour than the rest of the leaves.

On comparing the young specimens of Group C, varying in length from 74—108 mm., the first feature of special interest is the much greater length of the stalk of the specimen (12) from a depth of 397 metres compared with the length of the stalk of the other two specimens from shallow water.

The number of autozooids in the larger leaves of all the specimens is 5—6 and the length of the leaves is about the same, 5.5—6 mm. with a base 1.5—2 mm.

The length of the calyx of the autozooids is about the same as that of the adult specimens and, as the leaves are narrower, the form of the leaf is more like that of a *Pennatula Pearceyi* than of a *P. Murrayi.* There can be little doubt however that these specimens are small specimens of *P. Murrayi.*

The specimen 13 from Station 260 has a pale pink colour with almost white leaves and the colour extends further down the stalk than it does in any of the specimens of Groups A and B. Specimen 14 is almost colourless.

Microscopic examination of both these specimens shows that the cortex of the stalk is crowded with short rod-like spicules coloured red and 0.075 × 0.015 mm., in size in the case of specimen 13 and colourless and 0.10 × 0.012 mm. in size in the case of specimen 14.

This species was founded by KÖLLIKER in 1880 for a single specimen obtained by the "Challenger" expedition in 236 metres off the W. coast of Ceram, a locality not very far from the spot where the deep water specimens of Group B were found by the Siboga expedition.

It was a small specimen 140 mm. in length with a rachis $2^1/_2$ times the length of the stalk, the number of autozooids on the larger leaves was 9—10 and these leaves were 17 × 5.3 mm. in size. The leaves were described as transparent.

This "Challenger" specimen was probably a young form. It was found in a depth of water intermediate between the depth of water in which the Siboga specimens belonging to Group A and Group B were found. It approximates to the shallow water group in the transparency and size of the leaves and to the deeper water group in the proportionate length of the stalk and in the number of autozooids in the larger pinnules.

These points suggest that the difference between these two groups is correlated rather with depth than geographical position.

Since the type species was described, many specimens have been recorded by BALSS (1910 p. 56) from Sagami bay in Japan at depths of 150 to 180 metres but none of them exceeding 300 mm. in length, two small specimens from the Maldives in 76 metres were recorded by myself in 1906, eighteen specimens were recorded by KÜKENTHAL and BROCH from off Great Nicobar in 296 metres of water of which the largest reached a length of 359 mm.

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More recently NUTTING (1912) has recorded a small specimen from Japanese waters, and I have in my laboratory five specimens collected by Prof. STANLEY GARDINER in 68 metres of water off the Seychelles.

As the species is one that can be determined without difficulty we may assume that in this case the identifications are correct and that the species has a wide distribution in the Indian Ocean and the Western pacific seas.

The species shows considerable variation according to depth and the following may be given as a general statement of its characters: —

Long and slender Pennatulas with a slender stalk showing an oval swelling at its upper end. Leaves long, narrow and pointed at the extremities composed of a single row of autozooids reaching a maximum of 20 in the largest specimens (600 mm.) transparent or very transparent in the shallow water forms. Autozooids provided with eight pointed calices, and united almost to the base of the calices. No spicules in the anthocodiae.

A large mesozooid with a calyx provided with two teeth opposite the dorsal edge of each leaf. The siphonozooids in rows between the leaves and in groups on the dorso-lateral line of the rachis. A broad track free from siphonozooids on the mid-dorsal aspect of the rachis.

Almost invariably brightly coloured red or red and yellow, the patterns in the shallower water forms being variegated.

Anatomical notes.

1. The Mesozooids. The large zooids situated close to the dorsal edge of the leaves of *Pennatula Murrayi* are such very conspicuous structures that the question naturally arises whether they are merely enlarged siphonozooids of the ordinary type or zooids of a different anatomical structure.

On external examination they may be distinguished at once, not only by their great size, as compared with the surrounding siphonozooids but also by the tubercle-like verruca on which they are situated armed with two opposite pointed teeth or spines (Pl. IX, fig. 66).

In some specimens the spicules which form these spines are of a different colour to the spicules of the surrounding parts of the rachis, being yellow instead of red, or red instead of yellow so that they can be seen even with the naked eye as a row of coloured spots extending the whole length of the dorso-lateral line of the rachis.

Another feature that may be noticed with a hand lens is that, instead of being tightly closed like the other siphonozooids, the mouths are usually widely open.

On making transverse sections of these large siphonozooids certain anatomical peculiarities are observed.

The wide open stomodaeum shows on one side, presumably the ventral side, a row of columnar ciliated cells, but the rest of it is lined by an epithelium of shorter cells which do not show cilia (Plate IX, fig. 67).

If this track of ciliated epithelium represents the siphonoglyph of these zooids, it is relatively but feebly developed. In width it extends only between the attachments of the two ventral mesenteries, instead of to the ventro-lateral mesenteries as in the ordinary siphonozooids

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and the epithelium is not so remarkably different from the epithelium of the other parts of the stomodaeum as it is in the ordinary siphonozooids.

It is probable that the whole of the epithelium of the stomodaeum is ciliated in life as it is in other zooids but it is only on this ventral band or track that they are strong enough to be preserved in the ordinary way.

The transverse sections also show that there are the ordinary eight mesenteries supporting the stomodaeum. These mesenteries however differ from the mesenteries of the ordinary siphonozooids in the fact that they bear powerful bands of muscles. The arrangement of these muscles appears to be rather complicated and I have not been able to trace them out satisfactorily through the whole length of the mesenteries, but in a transverse section taken in the middle of the stomodaeum (fig. 67) we find that the lateral mesenteries have muscles on both surfaces, whereas the dorsal and ventral pairs of mesenteries have a muscle band only on one surface.

In the siphonozooids of Pennatulacea there are no muscles or the muscle fibres they bear are so slender and scattered that they are not noticed in transverse sections. The mesenteries of the autozooids bear a band of muscle fibres on their ventral surface only. The mesenteries of these large siphonozooids of *Pennatula Murrayi* therefore differ as regards their musculature from both the other kinds of zooids.

A third important character shown by the large siphonozooids is that its coelenteric cavity opens directly into the lateral longitudinal canal (Plate IX, fig. 65 *Mes.*).

As this is such a very exceptional condition I have taken great pains to ascertain that this statement is absolutely correct. In the first place, by concentrating the light on the open mouth of one these large siphonozooids I failed to discover in any specimen a membrane or diaphragm between the cavity I was looking into and the sheath of the axis. This examination was made on specimens that had not been previously dissected in any way, in case such a membrane might be ruptured or destroyed in manipulating the specimens for section-cutting. Other specimens were then taken and slowly decalcified in weak Nitric acid. These specimens were imbedded and cut in a plane transverse to the axis of the rachis so that the sections passed longitudinally through the large siphonozooids. These sections showed that the material was well preserved and that practically no membranes had been broken in the manipulation. After careful examination of the series I am quite convinced that there is no membrane or diaphragm between the coelenteric cavity of the mesozooid and the lateral longitudinal canal but that there is complete direct communication between the former and the latter.

In one series, the cavity of the large siphonozooids passes outside the lateral longitudinal canal and opens into the ventral longitudinal canal.

There are no mesenteric filaments in the mesozooids or in the siphonozooids.

The investigation of the mesozooids seems to show clearly that they are not ordinary siphonozooids of a large size and that they are not young zooids in process of development into autozooids but a type sui generis. As I pointed out in 1903 (p. 688) the colony of *Pennatula Murrayi* is not dimorphic as the other Pennatulacea are, but trimorphic; or to be more strictly accurate if we include the Oozooid as another type of zooid, it is not trimorphic

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but quadri-morphic. As it is obviously inconvenient to continue the use of the words "large siphonozooids", I venture to suggest that they be called the "Mesozooids". But I think a more convenient word still may be proposed when their function is known.

The determination of their function can only be made, of course, by physiological experiment but it is worth while to consider what the anatomical structure and relations of these large siphonozooids suggest as regards their function.

As I showed in 1883 (p. 694) that the function of the long cilia of the siphonoglyph of Alcyonium is to produce an inhalent current of water and suggested at the time that the siphonozooids of the dimorphic Alcyonaria, provided as they are with a remarkably well developed siphonoglyph and no digestive organs, also produce inhalent currents of water to circulate in the canals and spongy tissues, it seems probable that the mesozooids are not inhalent zooids. The absence of tentacles and mesenteric filaments proves that they have no digestive functions.

BALSS has suggested that they are genital openings (Geburtsöffnungen) on the ground that he has seen an egg in the mouth of one of them. This view is to me quite untenable. The gonads are formed always on the mesenteries of the autozooids never in any pennatulid on the mesenteries of the siphonozooids and I have never seen them, in any of the many sections, on the mesenteries of these mesozooids. How is it possible then for the ripe eggs to pass from the coelentera of the autozooids to the coelentera of the mesozooids?

The specimen I have dissected (N° 5) is a female with many nearly ripe eggs in all the leaves, but I have not seen a single egg in the coelenteric cavity of any mesozooid either by macroscopic or microscopic investigation. There can be little doubt that the eggs and sperms of *Pennatula Murrayi* escape to the exterior in the usual way through the mouths of the autozooids.

The suggestion I would make is that their function is to expel water with great rapidity from the principal canals of the body of the colony, that they are exhalent rather than inhalent zooids. This view is suggested by the facts that the siphonoglyph is weak and that in the preserved material the mouth is almost invariably open. The siphonozooids whose function it is, we believe, to pump water into the canal system have a strong siphonoglyph and when they come into contact with the preservative fluid close their mouths. If the function of the mesozooids is to expel water it might be expected that this function would come into play at the moment when they are hauled on deck or plunged into spirit and the mouths would remain open.

Pennatula Murrayi is not the only species in which specially modified zooids of this kind have been found. They also occur in *Pennatula grandis*. In the genus *Pteroeides* there is a band of zooids on the ventral track which are larger than the ordinary siphonozooids of the leaves and exhibit like the mesozooids of Pennatula a weak siphonoglyph and muscular bands on the mesenteries. A careful description of these zooids in *Pteroeides griseum* has been given by NIEDERMEYER (1911 p. 38). A similar band of zooids occurs on the ventral side of the rachis in *Sarcophyllum*. In the description of the development of *Renilla*, WILSON (1884) relates that the first formed bud persists as an exhalent zooid, and in the description of the development of *Pennatula phosphorea*, JUNGERSEN (1888) commenting on WILSON's discovery

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refers to a group of zooids at the distal end of the rachis which he calls "Scheitelpolypen" and suggests that they are also exhalent in function.

Further investigation however is needed to determine whether these zooids of *Renilla* and *P. phosphorea* are or are not of the same nature as the mesozooids.

2. The brown tubes. Turning now to another feature shown in the sections, we find on examination of the dorsal track in the neighbourhood of the large siphonozooids a series of bent tubes lined by a specialised epithelium that form a means of communication between the sub-cutaneous system of endodermal canals (the "solenia") and the lateral longitudinal canals (Plate IX, fig. 68 *b.t.*) I have called them "brown tubes" because in unstained sections they are usually conspicuous by their brown colour and because I do not wish to assume without further evidence that they are homologous with the radial canals of the Virgulariidae. The epithelium lining the tubes is columnar, has a strong affinity for stains and is undoubtedly ciliated. At each end of the tube there is what appears to be a tumid rosette-shaped funnel mouth on which the cilia are usually well preserved. These funnels remind one of the nephrostomes of some of the higher animals.

I have not yet determined accurately the number and arrangement of these tubes throughout the rachis. In the sections I have examined through the middle of the rachis there are several tubes close to each of the mesozooids (Fig. 67) but in the space between one mesozooid and the next on the same side of the rachis, there are also a few. We notice here, then, a difference between the brown tubes and the radial canals of the Virgulariidae. In all the transverse sections of Virgularia the radial canals can be found. They form in fact a continuous series extending through the whole length of the rachis. The brown tubes on the other hand form an interrupted series, occurring principally opposite to the dorsal border of each leaf and rarely between the leaves. Several sections in a series taken between the leaves show no brown tubes at all. Whether there is any change in this arrangement at the upper or lower end of the rachis of the individual and whether the arrangement here described is constant or not in all individuals has not yet been ascertained.

In the transverse sections described above a number of siphonozooids can be seen opening externally at the sides of the dorsal track. The cavities of these siphonozooids are connected below with the system of wide solenia beneath the cortex, these canals communicate with the lateral longitudinal canals by way of the brown tubes, but there is also a communication between the cavity of the mesozooid and this system of sub-cortical solenia so that fluids could pass to or from the mesozooids directly into the lateral longitudinal canals or indirectly — by way of the endodermal canals and the brown tubes — into the dorsal longitudinal canal. If it is a fact that the brown tubes are only found in the neighbourhood of the mesozooids, it seems probable that the main function of the brown tubes is to bring the mesozooids into relation with the dorsal longitudinal canal and this view would receive additional support if it could be shown that brown tubes only occur in the species of Pennatula, that have the mesozooids. The study of the anatomy of *Pennatula phosphorea*, one of these species without mesozooids, has not yet revealed the presence either of brown tubes or radial canals and it is difficult to believe that such careful and skilled observers as Kölliker and Marshall would

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have overlooked them had they been present but I cannot press this point until further investigations have been made.

1. *Pennatula Naresi* Kölliker.

Pennatula Naresi Kölliker 1880. "Challenger" Pennatulida. p. 2, Pl. I.
Pennatula Naresi Balss 1910. Japanische Pennatuliden. p. 56.
Pennatula Naresi Kükenthal and Broch 1911. "Valdivia" Pennatulacea. p. 355.
Pennatula Naresi Nutting 1912. Pacific Alcyonaria. p. 30.

Stat. 45. 7°24′ S., 118°15′ E. Off Sumbawa Island. 794 metres. 4 Ex.

The four specimens were measured with the following result: —

	1.	2.	3.	4.
Total length	630 mm.	700 mm.	610 mm.	560 mm.
Length of stalk	90 „	100 „	85 „	90 „

Further measurements of N° 1 gave: —

Diameter of bulbous enlargement of stalk . . .	15 mm.
Diameter of the lower part of stalk	10 „
Dorso-ventral thickness of rachis	4·5 „
Number of autozooids in larger leaves	25
Number of leaves on each side about	60
Of which there were rudimentary	6
Length of leaves	15 mm.
Breadth of leaves at the base.	12 „

The other specimens are more or less damaged.

The leaves are very obliquely set upon the rachis at intervals of about 10 mm. As compared with the leaves of *P. Murrayi* they are very thick and fleshy. They are triangular in shape and the free edge is sinuous in outline.

The autozooids are arranged in two distinct rows at the free edge of the leaves and the cylindrical calices, with a maximum length of 2 mm., that protect their distal ends are provided with a number of projecting yellow spicules.

It is difficult to determine whether in life these projecting spicules are arranged in eight or any other number of definite points. In the specimens as they are preserved they are very irregular.

The anthocodiae are all contracted.

The siphonozooids are very numerous. There is a broad band of them between the leaves which meets another continuous band running along each side of the dorsal track.

Between these two bands of siphonozooids there is a broad mid-dorsal track free from siphonozooids. Opposite the dorsal edge of each leaf there is a cluster of 10—12 siphonozooids which appear to be larger than the others and are situated on low verrucae distinguished by their yellow spicules. These coloured clusters have to the naked eye, the general appearance of a single mesozooid but there is nothing to suggest any important difference between these rather larger siphonozooids and the others.

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The stalk is remarkable in this species for its great thickness as compared with the rachis. The swelling at the upper end of the stalk has a diameter 3 times as great as the dorso-ventral diameter of the rachis and the cylindrical part below this swelling a diameter twice as great as that diameter. This peculiarity occurs in all the specimens in the collection and in the type specimen of the species in the British Museum.

The spicules are very numerous and crowded in all parts of the colony. The large yellow spindle-shaped needles of the calices are 0.8—1.2 mm. in length and 0.04—0.05 mm. in greatest breadth. The larger red needles of the leaves are 0.5—0.7 mm. in length by 0.03—0.04 mm. in breadth. In the cortex of the swelling of the stalk there are numerous tightly packed spicules much smaller in size and showing a constriction in the middle. The majority of them are 0.1—0.15 mm. in length and 0.02—0.03 mm. in breadth but there are several that are much smaller than that. Similar spicules but smaller in average size are found in the cortex of the lower cylindrical part of the stalk. In the cortex of the dorsal track of the rachis spicules intermediate in size and shape between the spicules of the leaves and those of the cortex of the stalk are found in great numbers.

As the anthocodiae are all retracted and not very well preserved it is not possible to give a complete account of their spicular armature. The tentacles are however provided with numerous red ridged rod-shaped spicules of which the largest are about 0.04 × 0.01 mm.

The colour of these specimens is roseate red but the calices and the group of siphonozooids on the dorsal edge of each leaf are yellow. The upper end of the swelling on the stalk is darker red than any other part of the colony. The cylindrical part of the stalk below the swelling is pink.

The injuries that all the specimens of this species have suffered from may be due to a natural brittleness of the tissues, but there can be no doubt that they are not as well preserved as the specimens of *P. Murrayi*.

A series of sections was made through the large siphonozooids at the base of the leaves but it was found that a study of their histological structure could not give trustworthy results.

The type specimen of this species was obtained by the Challenger expedition at a depth of 630 metres off the coast of Japan and the same species has been described by Balss from 200—730 metres, by Nutting from 1097 metres, and by Kükenthal and Broch also from Japanese waters in 200—730 metres.

The type specimen was 300 mm. in length and the specimen described by Kükenthal and Broch 445 mm. in length. Balss describes several specimens from Japanese waters varying in length from 140—570 metres and Nutting describes specimens 400 mm. in length. Three of the four specimens collected by the Siboga expedition are therefore the longest that have been recorded.

The species appears to be related to *Pennatula bellissima* of Fowler (1888) from the Bahamas but it differs mainly in the very much shorter and smaller leaves. The total length of Fowler's specimen was only 178 mm. but the leaves were 45 mm. in length. In the Siboga specimens of *P. Naresi* which are much larger, the larger leaves are not over 20 mm. in length.

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Apart from this and other differences referred to by FOWLER the geographical position of his species renders it improbable that it is identical with a species that has up to the present time been found only in Japanese and Malayan waters.

2. *Pennatula* sp.?

Stat. 251. 5° 28′ S., 132° 0′ E. 204 metres. 1 Ex.
Stat. 284. 8° 43′ S., 127° 16′ E. 828 metres. 6 Ex.

The specimens from Station 284 are all more or less damaged and on the record from the Station is the statement that the net was torn. The largest specimen, which is also the one that is the least damaged, is 160 mm. in length and quite colourless. The other specimens in this tube show coloured leaves with red and yellow spicules.

The specimen from Station 251 is also damaged. It is about 90 mm. in length and has a yellow stalk and orange coloured rachis.

The rough texture of the cortex of the stalk, the shape of the leaves, the colour variations and the arrangement of the siphonozooids suggest that they are all young specimens of *Pennatula Naresi*.

The absence of any intermediate forms between these small specimens and the very large specimens of *P. Naresi* from Station 45 renders this identification very uncertain.

On the other hand the characters that can be made out show conclusively that the specimens do not belong to either of the species *P. Murrayi* or *P. indica*.

3. *Pennatula indica* Thomson and Henderson. (Textfig. 37).

Pennatula indica Thomson and Henderson 1906. "Investigator" Alcyonaria. p. 113, Pl. VIII.
Pennatula indica Thomson and Simpson 1909. "Investigator" Alcyonaria, p. 285.

Stat. 221. 6° 24′ S., 124° 39′ E. Banda Sea. 2798 metres. 2 Ex.

These two specimens from very deep water come closest to THOMSON and HENDERSON's species but differ from it in some respects particularly in the remarkable length of the stalk. As this character, however, may be correlated with the great depth in which the specimens were found there does not seem to me to be sufficient reason for establishing a new species (cf. *P. Murrayi* p. 190).

The following table gives some of the measurements of the two specimens with that of one of the type specimens for comparison.

	1.	2.	Type specimen.
Total length	95 mm.	92 mm.	105 mm.
Length of rachis	39 „	35 „	55·5 „
Length of stalk	56 „	57 „	49·5 „
Number of leaves	13/12	7/9	17/19
Length of leaves	25 mm.	21 mm.	23.2 mm.
Breadth of leaves at base	2 „	2 „	3.2 „
Number of autozooids in a large leaf	5	5	11

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The long narrow leaves are inserted obliquely on the rachis and are bent at an acute angle towards the distal end of the rachis giving an effect like a loose tassle of autozooids very similar to that shown in the figure of the type (Th. and H. 1906 (2) Plate VIII, fig. 1).

On careful examination however the leaves differ from those of the type in being composed of fewer autozooids and in having a much longer free part for each autozooid below the calyx.

The whole leaf appears to be much more loosely built and reminds one of the shape of the leaf of *Pennatula phosphorea* var. *antarctica* Kükenthal and Broch (1811 Pl. XVII, fig. 24).

Along the dorsal border of the leaves there are some very large stout spicules attaining to a size of 3.2 × 0.15 mm. Some of these spicules present a peculiar outgrowth such as I have not observed in any other Pennatulid (fig. 37).

The autozooids. Each autozooid is armed with large longitudinally arranged spicules and bears a calyx supporting eight long spines.

Some of the anthocodiae are expanded and show that both tentacles and body wall are well provided with spicules.

The siphonozooids are very numerous being distributed in large numbers on both sides of a shallow median groove in the middle line of the dorsal track and extending between the leaves. These siphonozooids are situated on low verrucae protected by a fan-shaped arrangement of red spicules similar to that figured for the type (Th. and H. Pl. VIII, fig. 1*b*). The siphonozooids are all of approximately the same size and there are no mesozooids.

The long slender stalk has no swelling at the upper end but, in specimen 1. terminates below in a thin-walled bulb 5 mm. in length by 2 mm. in diameter. In this specimen the stalk is 2.5 mm. in diameter above but gradually narrows to a diameter of 1.5 mm. just above the bulb. The stalk of specimen 2. is rather larger in diameter above.

The spicules vary very much in size. Along the dorsal edge of the leaf there are spicules from 2.5—3.2 mm. in length with a maximum diameter of 0.15 mm. Some of these very large spicules show two or more tooth like outgrowths projecting from the side (fig. 37 B).

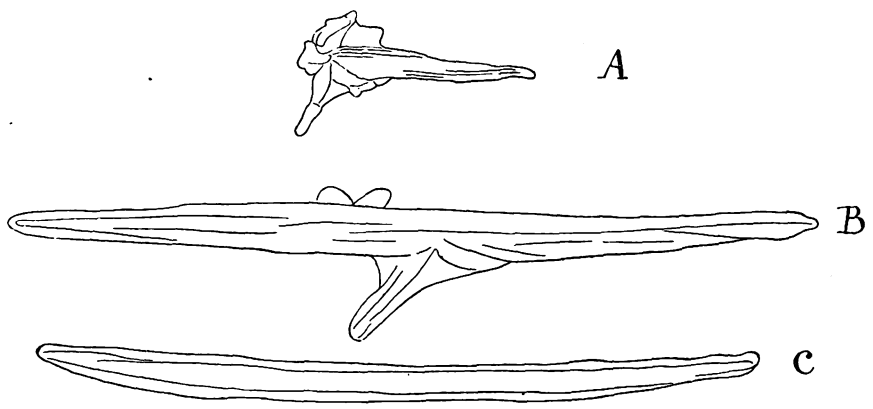

Fig. 37. Spicules of *Pennatula indica* showing two spicules (A & B) found near the base of the leaves with lateral outgrowths. × 40 diam.

The smaller spicules of the leaves and rachis are 3-flanged rods and needles of various sizes up to a length of 0.8 mm. and a diameter of 0.04 mm. The spicules of the calices of the siphonozooids are 0.3 × 0.03 mm. The axis of the tentacles is supported by rows of pink rods about 0.1 mm. in length by 0.04 mm. in breadth.

In the cortex of the upper part of the stalk (spec. 1) there are numerous scattered rods (0.13 × 0.04 mm.) and in the cortex of the end bulb rods of 0.08 × 0.03 mm.

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In the subcortical tissues of the bulb there are very numerous corpuscles about 0.005 mm. in diameter, both scattered and in groups.

The colour of the rachis of Specimen 1 is a uniform pink the greater part of the stalk pale yellow and the bulb brown. Specimen 2 has a very pale pink rachis but is otherwise like specimen 1.

The type specimens of this species were found in the Indian Ocean at depths of 847—1507 metres.

It is possible that they may prove to be identical with STUDER's variety *Pennatula distorta* var. *pacifica* from a depth of 3182 metres in Lat. 0° 7′ N. and Long. 81° 4′ E. (STUDER 1894 p. 55) of which we possess at present only a very brief description.

I do not agree with the suggestion of BALSS (1910 p. 58) that *P. distorta* is probably identical with MOROFF's (1902 p. 380) *P. phosphorea* var. *longispinosa*.

Pennatula indica is essentially a deep sea form with remarkably long narrow leaves. MOROFF's variety on the other hand has not been found in deeper water than 150 metres and has comparatively short leaves.

It is true that the Siboga specimens differ from the type in some important respects but, judging from the description given by MOROFF and BALSS of *P. phosphorea* var. *longispina* they differ still more from this variety.

It is a matter for further discussion whether *Pennatula indica* should be regarded as an independent variety of the very variable and widely distributed species *Pennatula phosphorea*, to which it is closely related — or stand as a separate species; but from the examination of only two small specimens of *P. indica* it appears to me that there is sufficient distinction between the two forms to justify the separation.

The principal points of difference between the Siboga specimens and the specimens collected by the "Investigator" in the Indian Ocean are: —

1. The greater length of the stalk in the former.
2. The smaller number of autozooids composing the leaves.
3. The greater size and peculiar form of some of the spicules of the leaves.

All these three characters may be correlated with the greater depth in which the Siboga specimens were found.

Genus **Scytalium** Herklots.

Scytalium Herklots 1858. Polypiers nageurs. p. 14, Plate VII.
Scytalium Kölliker 1872. Die Pennatuliden. p. 233, Pls IX & XV.
Pennatula splendens Thomson & Henderson 1906. "Investigator" Alcyonaria. p. 116, Pl. VIII.
Pennatula veneris Thomson & Henderson. Ibid. p. 115, Pl. VIII.
Scytalium Thomson & Simpson 1909. "Investigator" Alcyonaria p. 282.
Scytalium Balss 1910. "Japanische Pennatuliden" p. 48, Pl. II.
Scytalium Kükenthal and Broch 1911. "Valdivia" Pennatulacea. p. 310.

In the description of the genus Scytalium given by KÖLLIKER (1872) he says that the sea-pens of this genus are "long and slender and of the form (habitus) of Virgularians", and

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this description of them is quite consistent with the form of *S. Sarsii* of HERKLOTS and of the *S. Martensii* of KÖLLIKER.

In the more recent literature of the subject however, the forms, described by THOMSON and SIMPSON (1909 p. 282) as *Scytalium Martensii* var. *magnifolia* and by BALSS (1910) as *Scytalium splendens* do not appear to me to merit the term "long and slender".

If a comparison be made between the original figure given by HERKLOTS of the genus and the figure given by BALSS (1910 Pl. II) of *Scytalium splendens* it will be found that whereas the length of the former is 250 mm. and the maximum breadth of rachis including the leaves is 4 mm. or excluding the leaves 1.5 mm.; in the latter the length is only 190 mm. and the maximum breadth of the rachis including the leaves is 18 mm. and excluding the leaves 4 mm. The former is a figure of a long slender pennatulid, the latter is not.

The general external appearance of *Scytalium splendens* is like that of some species of Pennatula and it is not surprising that the species was originally referred to Pennatula by THOMSON and HENDERSON; but the long slender sea-pens described by HERKLOTS and KÖLLIKER are unlike any species of Pennatula so far as external form is concerned.

Species of *Scytalium* therefore may or may not be "long and slender".

Moreover in the original descriptions of the genus the number of autozooids in each leaf is a comparatively small one. In the descriptions of more recent date the number is a much larger one.

KÖLLIKER (1872 p. 234) for example says that in the original, type specimen of *Scytalium Sarsii* the number of autozooids in the leaves varies from 18—20 and in the type specimen of *S. Martensii* from 9—13. In striking contrast with these figures are those of subsequent authors which may be expressed in a table:

Species	Author	Locality	Number of autozooids in the leaf
Scytalium Sarsii	KÖLLIKER	North sea?	18—20
S. Sarsii	KÜKENTHAL & BROCH	Red sea	—36
S. Martensii	KÖLLIKER	Chinese sea	9—13
S. Martensii, var. *magnifolia*	THOMSON & SIMPSON	Andaman islands	18—21
S. splendens	BALSS	Japan	—50
S. Martensi	KÜKENTHAL & BROCH	Japan	—60

I do not deny that the specimens described by these later authors belong to the genus *Scytalium* but if they do it is necessary to amend the original description of the genus so as to omit the word slender and to separate the forms with a large number of autozooids into distinct species.

In their discussion of *Scytalium Martensii*, KÜKENTHAL and BROCH (1911 p. 315) consider that the difference in the number of the autozooids in each leaf between BALSS' *S. splendens*, KÖLLIKER's specimen of *S. Martensii* and THOMSON and SIMPSON's specimens of the last named species is only a matter of age.

"Untersuchen wir nun, worin sich vorliegende Art (i. e. *S. splendens*) von dem KÖLLIKER' schen *Scytalium Martensi* unterscheiden soll, so finden wir, dass *S. Martensi* kleinere Blätter und

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weniger Polypen an den Blättern haben soll. Eine var. *magniflora* die THOMSON und SIMPSON beschreiben, nimmt indessen schon eine vermittelnde Stellung ein, und wenn wir ausserdem die Grösse der KÖLLIKER'schen Exemplare bedenken, so können wir sehr wohl die Unterschiede als Altersunterschiede auffassen".

But KÖLLIKER's specimen was 493 mm. in length and THOMSON and SIMPSON's specimen of the variety "*magnifolia*" was only 285 mm. in length. In other words the longer specimen has the fewer autozooids and there is no reason to suppose that the latter is an older specimen than the former.

The largest specimen of *Scytalium splendens* described by BALSS was 600 mm. in length with up to 50 autozooids in each leaf. THOMSON and HENDERSON's specimen of *Pennatula splendens* 340 mm. in length had 60, and THOMSON and SIMPSON's small specimen of *S. Martensii*, var. "*magnifolia*", 285 mm. in length, had 18—21 autozooids in each leaf.

If we include KÖLLIKER's specimen, of *S. Martensii*, we find that there is absolutely no correlation between the length of the stock and the number of the autozooids in the leaves.

There seem to be two sets of specimens included in the species *S. Martensii* of KÜKENTHAL and BROCH which may be arranged as follows: —

I.

Authors	Specific name given by author	Total length in mm.	Number of autozooids in a leaf
KÖLLIKER	*S. Martensii*	493	9—13
THOMSON & SIMPSON . .	„	600	6—13
HICKSON (This memoir) .	„	635	10—12

II.

THOMSON & SIMPSON . .	*S. Martensii* var.	285	18—21
THOMSON & HENDERSON	*Pennatula splendens*	340	60
KÜKENTHAL	*S. Martensi*	420	—60
BALSS	*S. splendens*	600	—50

If we consider these two sets as distinct species for which we retain the name *S. Martensii* and *S. splendens* respectively we find that in addition to the character of the number of autozooids in each leaf, the former (*S. Martensii*) differs from the latter (*S. splendens*) in having only one horizontal row of siphonozooids between the leaves. In THOMSON and SIMPSON's *S Martensii* var. *magnifolia* there are two irregular rows of siphonozooids, in THOMSON and HENDERSON's specimen of *Pennatula splendens* (i. e. *S. splendens*) "rows", in BALSS's specimen and in KÜKENTHAL's specimen more than one row.

The specimen described by KÜKENTHAL and BROCH under the name *S. sarsi* differs materially from those described by KÖLLIKER.

KÖLLIKER's first specimen was 495 mm. in length and had 18—21 autozooids in a row, one of the "Challenger" specimens was 400 mm. in length and the number of autozooids shown in the figure of it is 23. KÜKENTHAL's smaller specimen 310 mm. in length had as many as 36 autozooids in a row.

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It is difficult to understand from KÜKENTHAL and BROCH's account what are the essential differences between *S. Sarsii* and *S. Martensii.*

If we accept KÖLLIKER's definition of the species and reject KÜKENTHAL's the difference between them is quite clear as expressed in a tabular form by THOMSON and SIMPSON (1909 p. 284).

Scytalium splendens, originally described by THOMSON and HENDERSON as *Pennatula splendens* differs from the other two species in being relatively stout with large leaves and numerous autozooids on each leaf.

Scytalium veneris, THOMSON and HENDERSON is clearly related to *S. splendens.* The largest specimen at present known is only 243 mm. in length and has 36 autozooids in a leaf. It differs also from *S. splendens* in the peculiar arrangement of the lower leaves, the arrangement of the siphonozooids and in other characters.

In the Siboga collection there are three specimens from off the coast of Timor that are related to *Scytalium splendens* but differ from it in the presence of a digitiform process (Pl. VIII, figs 55 & 56) on the calyx of the autozooids similar to that in *S. tentaculatum* and in other characters. This new species is named *S. Balssii.*

The six species of the genus may be arranged as follows: —

A. With a digitiform process on the calyx of each autozooid.
- *a.* With a small number of undeveloped leaves . . . *S. tentaculatum* Köll. (1880 p. 10)
- *b.* With a large number of undeveloped leaves . . . *S. Balssii* n. sp.

B. With digitiform processes on the calices rare or absent.
- *a.* Specimens of 400—600 mm. with 6—13 autozooids in each leaf . . . . . *S. Martensii* Köll.
- *b.* Specimens of 400 mm. with 18—25 autozooids in each leaf . . . . . *S. Sarsii* Herk.
- *c.* Specimens of 243 mm. with 36 autozooids in each leaf. *S. veneris* T. and H.
- *d.* Specimens of 400—600 mm. in length with 50—60 autozooids in each leaf . . . . . *S. splendens* T. and H.

Scytalium is undoubtedly a well defined genus although some of the characters that have been used for its definition must be abandoned. As mentioned above, the species that were first described are very slender in build and have a superficial resemblance in form to some of the Virgularias but others are much more robust and approach some of the species of *Pennatula* in their form.

The leaves in some species are very small in others large in proportion to the total length of the pen and there is a wide range of difference between the species as regards the number of autozooids in a fully developed leaf and as regards the manner in which the leaves are inserted on to the rachis.

In the original description of the genus, KÖLLIKER (1872 p. 233) speaks of a calyx in the autozooids "Polypen in deutlich gesonderten Kelchen enthalten". BALSS (1910 p. 48) considers that the definition of the genus must be amended and the reference to the calyx omitted.

The difference between these authors is probably only a difference of their interpretation

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of the word calyx. If the calyx is "the lower part of the body wall of an autozooid which is more or less sharply defined from the upper part by its thickness" there is no calyx, but if it is regarded as an essential feature of the calyx, whether it is thickened or not, that the upper part (anthocodia) is capable of being withdrawn into it there is a calyx in, at least, some species.

A glance at the figure given by KÖLLIKER (1880 Pl. VI, fig. 13) of *S. tentaculatum* is quite convincing that in that species the anthocodia is capable of retraction and it is perfectly certain also that in *S. splendens*, *S. veneris* and *S. Balssii* the anthocodiae can be withdrawn more or less into the protection of the lower part of the body wall.

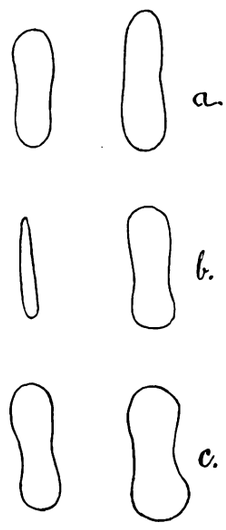

Fig. 38.
Spicules of the three species of *Scytalium*. × 500 diam.
Sc. Balssii (a).
Sc. Sarsii (b).
Sc. Martensii (c).

The character in which the known species of the genus have a remarkable similarity is the colour, shape and size of the spicules.

THOMSON and SIMPSON refer to these spicules as "needles" but I venture to suggest from the description and measurements they give of them that this is a misnomer. KÜKENTHAL and BROCH refer to them as biscuit shaped plates "biskuitförmige Platte" but as the biscuits of some countries are of many shapes this description is hardly precise enough for international usage.

In all the species I have examined the largest spicules of the leaves and rachis are flat plates oblong in outline with very rounded angles and a constriction in the middle and their measurements are within a few micromillemeters of .035 mm. in length and .015 mm. in breadth across the middle (Fig. 38). These spicules are by far the most numerous in all parts except in the base of the stalk. A few forms almost as large as these are oval in outline and some not quite so regular. There may also be smaller spicules that are very narrow, a few small triplets or quadruplets and some smaller granules of irregular shape. I believe that all these smaller forms are young stages in the development of the first type.

In looking through a number of preparations I have found it impossible to give any general statement of difference between the spicules of the leaves and rachis as regards their shape and size in the species examined; except that in *S. Martensii* there are some spicules that seem to be exceptionally broad .035 × .02 mm. KÖLLIKER gives the following measurements of the spicule length; *S. Sarsii*, .053 mm.; *S. Martensii*, .07 mm.; *S. tentaculatum*, .038 mm. THOMSON and HENDERSON give the measurements of the spicules of *S. veneris* as .04 × .02 mm. and of *S. splendens* as .04 × .02 mm.; BALSS gives the measurements of the spicules of *S. splendens* as .055 × .02 mm. If we compare these measurements of the spicules of *Scytalium* with those of other genera and allow for differences of method in estimating the length and breadth it is obvious that there is a very remarkable constancy in the size of the spicules throughout the genus. Moreover, in all the species the spicules are said to have some shade of red, some may be paler than others and in some cases spicules that appear to be quite colourless have been seen, but in all species red spicules of this definite form and size are a characteristic feature of their structure.

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The axis is, in all species, four sided with very rounded angles. I have examined a great many of the 100 specimens of *S. Martensii* so as to ascertain if in some cases the axis is cylindrical but have found none. When the dried surface is examined by the microscope in reflected light it shows delicate longitudinal ridges but without the striations so characteristic of some of the species of *Virgularia*.

There are no dorsal radial canals either in *S. Sarsii* or *S. Martensii*. Below the superficial epithelium of the former there is a layer of longitudinal muscles and below that a wide meshwork of solenia lined by ordinary endoderm and these canals communicate with the main dorsal longitudinal canal.

The ripe gonads in all the species I have examined are found in the leaves in the middle region of the rachis, never in the region of the immature leaves.

Distribution. The genus has been found in the seas off China, Japan, the Philippine Islands, the Malay Archipelago and the Indian Ocean at depths of 19 to 186 metres. The locality of the type specimen of *S. Sarsii* is given by HERKLOTS as "Mers du Nord" but until it is confirmed by subsequent discoveries I am inclined to regard this locality as doubtful.

The distribution of the specimens in the Malay Archipelago does not show any clear correlation between structure and depth of water.

The specimen of *S. Sarsii* from 31 metres off Makassar shows 25 autozooids in the leaf, the specimen from 88 metres in the Java seas shows 18—20, and the specimens of *S. Martensii* from 112 metres off Timor show only 12; but the number of autozooids in the leaf upon which so many other characters seem to depend cannot be correlated with depth as the specimens of *S. Balssii* with over 70 autozooids came from a depth of only 54 metres and the specimen which I believe to be related to *S. veneris* with 30 autozooids came from 69 metres.

The number of the spicules in the tissues also shows no correlation with depth. The specimen of *S. Sarsii* from Makassar (31 metres) has remarkably few spicules, of *S. Balssii* from 54 metres an enormous number crowding the tissues, and of *S. Martensii* from 112 metres comparatively few spicules.

It may be suggested that all these forms are only local varieties of one very variable species. It is possible that intermediate forms may be found but it is noteworthy that such widely different types as the very slender *S. Martensii* and the more robust *S. Balssii* are found off the coast of the same island (Timor).

As a result of these investigations I would suggest the following amended definition of the genus: —

Bilaterally symmetrical very slender to moderately stout sea pens with triangular leaves set either at right angles, obliquely or almost parallel with the long axis of the rachis. Autozooids with or without a calyx arranged in a single row which may become doubled or trebled at the ventral edge of the leaf.

The autozooids at the ventral edge of the leaf always much smaller than those of the dorsal edge. Siphonozooids between the leaves in a single row or very numerous, extending a short distance on to the dorsal track.

Spicules, in the leaves and usually on the rachis as well, in the form of oblong plates

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with rounded edges and constricted in the middle .03—.07 mm. in length. Some of the spicules always red in colour. Axis four-sided with rounded edges. No radial canals in the dorsal track. Gonads in the mature leaves.

1. *Scytalium Balssii* n. sp. (Plate VI, figs 40 & 41; Plate VIII, figs 55 & 56; Textfig. 39.

Stat. 282. 8° 25′ S., 127° 18′ E. Near Timor. 27—54 metres. 3 Ex.

There are three specimens of this new species, one large one and two smaller ones. The stalk of one of the smaller ones is damaged.

The largest specimen is 220 mm. in total length and the breadth across the rachis is 12 mm. It is certainly undeserving of the name "a slender (schlanke) sea-pen" although it is not so stout in build as some of the Pennatulas.

The stalk is 48 mm. in length, commencing above with an oval swelling 6 mm. in diameter and then narrowing below to a diameter of 2.5 mm. There is no well marked terminal bulb the stalk having a simple conical extremity.

The leaves are about 70 in number on each side and arranged alternately. The dorsal autozooid of the leaf is 5 mm. in height and the total length of the leaf when measured at the base of insertion is 10 mm. The base of insertion of the leaf starting from the dorsal side is at first at right angles to the longitudinal axis of the rachis, it then bends sharply in the direction of the distal extremity and ends by being parallel with the longitudinal axis of the rachis. On the ventral side the leaves of opposite sides run parallel and in contact with one another for some distance.

The autozooids. Each leaf in the middle region of the rachis is composed of about 33 autozooids. The anthocodiae are not fully extended. In some cases the tentacles are bent over the mouth, in others the anthocodiae are partially retracted into the calyx. From the calyx of each autozooid there projects a single pointed digitiform process, similar to that described by KÖLLIKER (1880, p. 10) in *S. tentaculatum* and in this memoir on p. 213 in *S. Sarsii*. This process is found on the youngest leaves at the base of the rachis and on all the autozooids of the older leaves.

The siphonozooids are very numerous and situated in a long triangular patch between the leaves. This patch projects slightly on to the dorsal track, so that a single row of siphonozooids passes in many cases round the base of the dorsal autozooids connecting one group of lateral siphonozooids with the one above it. The part of the dorsal track between these lines of siphonozooids is about 2 mm. in breadth.

The axis is quadrangular with rounded edges.

The colour is very striking and is the same in all three specimens. It may therefore be regarded in this case as of some specific value. The rachis and the leaves are purple, the swelling on the stalk is a darker purple or almost blue and this fades away below into the very pale yellow colour of the stalk. The anthocodiae appear to be yellow and so is, usually, the digitiform process of the calyx. The siphonozooids also appear to be yellow. I am not sure, however, that this yellow appearance is not really a contrast effect as I can see no reason for the yellow colour. The purple colour is due to the spicules.

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The spicules when seen singly under the microscope seem to be red. It is only in mass that they are purple. They are crowded on the calices and on all parts of the leaves rendering the latter quite opaque. A few red and some pale spicules extend into the digitiform processes and there is a row of spicules in the tentacles of the autozooids. The superficial layers of all parts of the rachis are crowded with the same spicules, but in the swollen part of the stalk the spicules appear to be more crowded together than anywhere else.

Fig. 39.
Spicules of *Sc. Balssii*.
× 200 diam.

In all parts of the colony the spicules are of the same shape and size. They are flattened plates oblong in shape with rounded angles and slightly constricted in the middle, varying from .03—.04 mm. in length and a maximum breadth of .012—.015 mm. A few smaller spicules of a different shape may be found among the others but all these odd ones I take to be stages in the development of the larger and far more numerous spicules described above.

The two smaller specimens were 114 mm. and 86 mm. respectively in length. In the longer one of the two the number of autozooids in the leaves was 15 and the length of the dorsal autozooid 1.5 mm.

An important point of difference between these younger forms and the older one is that the base of insertion of the leaves is from its beginning at the dorsal edge set at an acute angle with the axis as they are in the type specimens of *S. splendens*.

There can be no doubt that this species is most closely related to *Scytalium splendens* Thomson and Henderson (1906 (2) p. 116). It differs from it in two particulars.

The insertion of the leaves of the larger forms (220 mm.) is set at right angles to the longitudinal axis at their beginning and not parallel with it. The autozooids bear a digitiform process on the calyx.

As regards the first point; the type specimen of *S. splendens* was 272 mm. in length and the leaves are said to be "almost parallel to the long axis of the rachis" and BALSS describing another specimen (600 mm. in length) of the same species, 600 mm. in length, says "Diese Art unterscheidet von dem *Scytalium Sarsii* durch die Gestalt der Blätter, die viel grösser und höher sind, und durch ihre Befestigung, in dem sie nicht schief an der Achse sondern genau in der Längsrichtung nach oben aufgereiht sind".

As regards the second point, the digitiform processes are so conspicuous and so constant that it is quite impossible to suppose that both authors and artist could have overlooked them had they been present in *S. splendens* (Plate VIII, figs 55 & 56). Another point of difference is that the leaves are much smaller in relation to their total length in the new species than they are in *S. splendens* and the number of autozooids in each leaf smaller. There is an important resemblance between this species and *Scytalium tentaculatum* Köll. from 18—22 metres off the Philippines in the presence of the digitiform process on the calyx of each autozooid but there are many points of difference. *S. tentaculatum* is evidently from the measurements and figures a much more slender Pennatulid, of the build of *S. Sarsii*, to which it is more closely related.

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It is evident also that the spicules are not so crowded together in all parts of the rachis and leaves. It is unfortunate that KÖLLIKER does not mention the number of autozooids on each leaf but as he says that it is closely related to *S. Sarsii* in many respects it seems probable that there are fewer autozooids than in the new species. The very short series of undeveloped leaves at the base of the rachis is a point of difference between *S. tentaculatum* and both *S. Sarsii* and *S. Balssii.*

A short diagnosis of the new species may read as follows: — A rather stout species of *Scytalium*, with large leaves, about 33 autozooids in the larger leaves, every one provided with a digitiform process of the calyx. Siphonozooids very numerous, arranged in a triangular patch between the leaves and extending on to the dorsal track as a single longitudinal row. Colour of the rachis purple. Malay Archipelago 27—54 metres.

2. *Scytalium Martensii* Kölliker. (Plate VI, figs 37, 38, 39).

Scytalium Martensii Kölliker. 1872. Die Pennatuliden. p. 236, Pl. XV, figs 125 & 126.
Scytalium Martensii Thomson and Simpson 1909. "Investigator" Alcyonaria. p. 282, Pl. V.
Scytalium Martensi (ex parte) Kükenthal & Broch. 1911. "Valdivia" Pennatulacea. p. 313.

Stat. 260. 5° 36′ S., 132° 55′ E. Kei islands. 90 metres. 1 Ex.
Stat. 289. 9° 0′ S., 126° 24′ E. Off S. Coast of Timor. 112 metres. ca 100 Ex.

There were about 100 specimens of this species tied up in one bundle from Station 289. Nearly all of them were quite perfect but there were also some fragments.

The longest one that I measured was 635 mm. with a stalk 115 mm. in length, the shortest 175 mm. with a stalk 35 mm. in length. The majority ranged between 500 mm. and 600 mm. in total length and in all (30) specimens that I measured the total length was about five and a half times the length of the stalk.

There is considerable variation in the colour. Some of the specimens appear to the naked eye to be colourless, others show reddish leaves, others again red leaves and red rachis and finally in others the red spicules extend on to the stalk. There is one feature they have nearly all in common and that is a small patch of red spicules that can be seen with a hand lens in the angle between the calices of the autozooids.

The redness is in no way correlated with size. Some of the longest specimens are quite pale and the most highly coloured specimen in the collection is only 320 mm. in total length.

I give below in parallel columns the measurements of a large specimen and of KÖLLIKER's type specimen.

	Siboga specimen.	KÖLLIKER's type.
Total length	600 mm.	493 mm.
Length of the stalk	102 „	92 „
Length of the rachis.	498 „	401 „
Diameter of the stalk bulb	2 „	1.6 „
Diameter of the stalk above the bulb	1 „	1 „
Diameter of the middle of the rachis	5 „	4.5 „
Length of the dorsal edge of the leaf	2 „	1.8—2 „
Number of autozooids in the leaves	10	9—13

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The number of autozooids in the leaves is not constant and the figure given in the column is that of a leaf situated 100 mm. from the distal end of the rachis. If the figures given in these columns are compared with those given by THOMSON and SIMPSON (1909 p. 283) of their specimen of the same species and by BALSS (1919 p. 49) of *Scytalium splendens* one must be convinced that these authors were quite correct in regarding *S. Martensii* and *S. splendens* as distinct species.

It is also difficult to understand why KÜKENTHAL and BROCH included in the species *S. Martensi* a specimen 420 mm. in length, with as many as 60 autozooids in a leaf. If the number of autozooids in a leaf depends upon the age of the specimens, one would have expected to find some specimens among the 100 examined with forty or fifty autozooids in a leaf but the largest number I have found in the longest specimen was only twelve.

There is, it is true, some correlation between length and the number of autozooids in a leaf. In the longest specimen there were 12 at a distance of 100 mm. from the distal extremity and this seemed to be the maximum number. In a specimen 285 mm. in length there were only 5 at a corresponding distance from the distal extremity.

The rachis, in the middle region, is quadrangular and there is a well marked dorsal track extending the whole length, 0.6 mm. in width. The leaves are usually situated opposite to one another on the rachis and pass obliquely from the dorsal towards the ventral side. They are triangular in shape, stand out at right angles to the rachis and do not overlap one another.

There is an extraordinary variation in the way in which the leaves are set upon the rachis even in a single specimen. Some of the leaves have the base of attachment at right angles to the long axis, in others it is almost parallel with the long axis as seen in Pl. VI, figs 38 & 39. Between these two extremes there may be found every intermediate variety. The leaves rarely meet on the ventral side, so that there is usually a broad track on the ventral tide of the rachis which in many specimens is marked by two broad bands of coloured spicules or is wholly red.

There is some variation in different parts of the rachis as regards the distance between the leaves but the average of a large number of measurements was 2 mm. so that, even when she leaves are artificially pressed against the side of the rachis, there is no overlapping.

At the proximal end of the rachis for an extent of about 40 mm. there is a long series of undeveloped leaves (Pl. VI, fig. 37). These have all the characteristic features of the genus, a large dorsal autozooid and a gradually diminishing series of smaller autozooids on its ventral side.

The autozooids do not exceed 12 in number in the largest specimens but usually there are not more than 9 or 10. Their calices occasionally show a digitiform process (Pl. VI, fig. 38 *d.p.*).

The siphonozooids are arranged in a single irregular row between the leaves (Pl. VI, fig. 38) and the number does not usually exceed the number of autozooids in the leaves. I have not observed any siphonozooids on either the dorsal or on the ventral track.

The stalk is slender and ends below in an oval swelling about twice the diameter of the upper part.

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Spicules. The distribution of spicules is very variable. In nearly all the specimens there is a cluster of red spicules in the angle between the calices of the autozooids.

Sometimes, the spicules extend on to the other parts of the leaves but usually the leaves are free from spicules and beautifully transparent. I have not observed any spicules in the tentacles or anthocodiae. In some cases there are no spicules on the dorsal track but on the ventral side there are two long lines of spicules extending the whole length of the rachis. In others both sides of the rachis are coloured with spicules, and occasionally the spicules extend on to the stalk. There are so many variations in the arrangement of the colour streaks due to these spicules that it would be dangerous to deny the occasional presence of spicules in any one part of the colony. A full description of every part of every one of the 100 specimens, alone could do justice to the beauty of these specimens.

The spicules have the usual form of flattened plates oblong in outline with rounded angles and slightly constricted in the middle. The only difference I can observe between the spicules of this species and the others is the presence of a good many examples that are rather broader than usual (.035 × .012 mm. and .035 × .02 mm.).

The axis is quadrangular in section with rounded angles. In the larger specimens it reaches a maximum thickness of 0.75 mm.

The single specimen from Stat. 260 is only 130 mm. in length, the rachis 76 mm. in length and the stalk 54 mm. It is evidently a young specimen of the same species.

A revised diagnosis of the species may read as follows: — A very slender species of *Scytalium* with very small leaves, with about 10 autozooids in the larger leaves, rarely provided with a digitiform process of the calyx. Siphonozooids arranged in a single row between the leaves. Colour very variable, but a group of red spicules nearly always present in the angle betweeen the calices. Indian Ocean, Japanese waters, and Malay Archipelago. Shallow water.

3. *Scytalium Sarsii* Herklots.

Scytalium Sarsii Herklots 1858. Polypiers nageurs. p. 14, Pl. VII, fig. 8.
Scytalium Sarsii Kölliker 1872. Die Pennatuliden. p. 234, Pl. IX, figs 80—81.
Scytalium Sarsii Kölliker 1880. "Challenger" Pennatulida. p. 10, Pl. VI.
? *Scytalium Sarsii* Kükenthal and Broch 1911. "Valdivia" Pennatulacea. p. 311.

Seat. 71. Makassar. 27—31 metres. 1 Ex.
Stat. 318. 6° 36′ S., 114° 55′ E. Java Sea. 88 metres. 1 Ex.
Stat. 319. 6° 16′ S., 114° 37′ E. Java Sea. 82 metres. 1 Ex. (broken).

The example of this species from Makassar was damaged at the proximal end. Its total length is 525 mm. but, in consequence of injury to the stalk, the relation of the stalk to the axis cannot be determined. The diameter of the rachis, including the leaves, at its widest part is 4 mm.

The leaves are arranged obliquely on the lateral sides of the rachis and meet on the ventral side leaving a free dorsal track about 1 mm. wide. They are set at a very acute angle to the rachis and overlap one another.

The dorsal edge of the leaf is 2.5 mm. in width and the leaf gradually narrows down to a width of 1.5 mm. on the ventral edge.

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Each leaf is composed of about 25 autozooids and of these the first five or six on the dorsal side are arranged in a single row the others in two or three rows. Some of the larger autozooids have a digitiform process of the calyx similar to that of the autozooids of *Scytalium tentaculatum.*

These statements are based upon an examination of leaves taken at distances of 140 mm. from the proximal end and 210 mm. from the distal end or 175 mm. apart in the middle region of the rachis.

At the proximal end of the rachis the leaves rapidly diminish in width and there is a series of about 10 or 12 in which the leaves are represented by one prominent autozooid and a diminishing row of smaller ones.

The siphonozooids are situated between the leaves on a thickened belt of the skin and project a little way on to the dorsal track. They are scattered irregularly in three or four horizontal rows. In one preparation I have counted 44 siphonozooids and although this number may not be constant it is certain that the number of siphonozooids is greater than the number of autozooids in the neighbouring leaves.

The colour of the rachis and stalk of this specimen is white. The margins of the lower leaves are pink but the upper leaves are entirely white.

Spicules. Scattered on the calices of the autozooids of the lower region of the rachis there are numerous red spicules. They are not clustered together in the angle between the calices as is usually the case in *S. Martensii* but more evenly distributed.

Most of these spicules are oblong with rounded edges slightly constricted in the middle (fig. 37, p. 201). They are .03 mm. in length .01 mm. across in the middle and .015 mm. across at the ends. In addition to these there are some needles .03 mm. in length and very narrow, some oval in shape and a few more irregular.

From the greater number and constancy in size of the large oblong forms I believe that all the others represent stages in the growth of the oblong spicules.

The axis is quadrangular. At a distance of 210 mm. from the distal end it is 1 mm. thick at a distance of 140 mm. from the proximal end it is 1.5 thick.

The specimen resembles the figure and corresponds with the description of the type specimens given by HERKLOTS. It also corresponds with the diagnosis of the species given by KÖLLIKER in having the leaves closely set and overlapping, in the arrangement of the siphonozooids and in the size of the spicules. Minor points of difference are (1^0) that the number of autozooids is greater (25 instead of 20) but this difference may be correlated with the greater length; and (2^0) the absence of the red stripes of coloured spicules at the insertion of the leaves.

A more important point of difference perhaps is the presence of a definite tentacular process on the calyx of some of the autozooids similar to that which seems to be characteristic of all the autozooids in *Scytalium tentaculatum* (KÖLLIKER 1880 p. 10). A point of difference however between *Scytalium tentaculatum* and this specimen is that the series of undeveloped leaves at the proximal end of the rachis is a short one in the former and a comparatively long one in the latter and in KÖLLIKER's specimen of *Sc. Sarsii.*

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The original specimens described by KÖLLIKER came from an uncertain locality, the "Challenger" specimens were found in 18—36 metres off the Philippine islands and his specimens of *S. tentaculatum* came from another station off the same group of islands but of the same depth.

It is quite possible that the tentacular process that characterises the latter species is more variable than he supposed and that the species will eventually he merged with *S. Sarsii* but at present it seems advisable to keep them distinct.

The description of the specimen described, from the Red Sea, by KÜKENTHAL and BROCH as *Scytalium Sarsii* is so different from that of KÖLLIKER that I cannot believe it belongs to the same species. I am inclined to believe that the *Pennatula veneris* of THOMSON and HENDERSON (1906 (2) p. 115) is related to this species but as it comes from deeper water (100 fathoms) in the Indian Ocean and shows some difference in detail it had better be kept apart.

The specimen from Stat. 318 is very different in appearance to the one from Makassar being much more slender and having a bright red stalk. It is placed with *Sc. Sarsii* because the number of autozooids in a leaf is 18—20 and because the rachis is about 7 times the length of the stalk. In some respects however it is intermediate between *Sc. Sarsii* and *Sc. Martensii.*

The following are the principal measurements: —

Total length	470	mm.
Length of rachis	410	„
Length of stalk	60	„
Width of dorsal track	2	„
Breadth of rachis	11	„
Greatest diameter of stalk	2.5	„

This is a long and very slender specimen with a colourless and very transparent rachis and red stalk. The leaves in the middle region of the rachis have 18—20 autozooids which are beautifully expanded and show no trace of a digitiform process. In the leaves examined there are no spicules except in the body walls of the anthocodiae but even in that region they are so few in numbers that they do not give a pink colour when examined with a simple lens. Judging from the colour the spicules must be very scarce in all the full grown leaves; but in the smaller leaves near the base of the rachis they are rather more plentiful.

The leaves are inserted on the rachis at such a very oblique angle, that they are almost parallel with the axis. The leaves do not overlap except at the upper end and there only very slightly.

The siphonozooids are arranged in a single row of 20—28 at the base of each leaf. In some places there is an incomplete second row. In this respect the specimen differs in a very pronounced manner from the Makassar specimen.

The stalk shows a very well marked oval swelling above, which is 2.5 mm. in diameter and bright red with crowded spicules. This swelling extends for a distance of 15 mm. and then gradually narrows to a cylindrical form 2 mm. in diameter which is not so deeply stained with spicules.

The axis is quadrangular and 1.2 mm. across at a distance of 90 mm. from the base.

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The spicules of the stalk have the usual form, .047 mm. in length .017 mm. across in the middle and .021 mm. across at the ends.

The specimen corresponds with *S. Sarsii* in the number of autozooids in a leaf and in the greath length of the rachis.

The specimen from Makassar was so damaged that the measurement of the stalk could not be determined but in two of the specimens described by KÖLLIKER (1880 p. 10) 400 mm. and 324 mm. respectively in total length, the length of the stalk was 52 mm. and 48 mm. or approximately 1 : 7.8 and 1 . 6.7. In this specimen the ratio is 1 : 6.8.

The third specimen from Stat. 319 was so badly damaged that general measurements cannot be given; but although the largest leaf examined had only 12 autozooids, the absence of spicules in the leaves and the colour of the stalk suggest close affinities with the other more perfect specimen from the Java Sea.

A revised diagnosis of the species may read as follows: — A moderately slender Scytalium with leaves of medium size, about 25 autozooids in the larger leaves, some of them provided with a digitiform process on the calyx. Siphonozooids arranged in two or three rows between the leaves extending a short way on to the dorsal track. The colour of the rachis and stalk usually white but the margins of the leaves sometimes pink. Indian Ocean and Malay Archipelago. Shallow water.

Small & damaged specimens of the genus *Scytalium*.

Stat. 1. 7° 27′ S., 113° 8′ E. Madura Strait. 37 metres. 1 Ex.
Stat. 49ª. 8° 23′ S., 119° 4′ E. Sapeh Strait. 69 metres. 2 Ex.
Stat. 105. 6° 8′ N., 120° 44′ E. Sulu Archipelago. 275 metres. 1 Fragment.
Stat. 204. 4° 20′ S., 122° 58′ E. Off Buton. 75—94 metres. 1 Ex.

Specimens of this genus are very liable to receive injury in the dredge and in some cases the injuries are such as to make accurate determination impossible. A few notes on these specimens may be of use for recording the distribution of the genus in the Malay Archipelago.

The specimen from Station 1 is about 200 mm. in length. The margins of the leaves are red but the rachis and stalk are white. The autozooids are contracted and the calices show many spicules of the characteristic form. It is probably a specimen of *S. Sarsii*.

One of the specimens from Station 49ª is 105 mm. in length with expanded autozooids, the crown of spicules at the base of the anthocodiae is similar to that of *S. Sarsii*.

The larger specimen from Station 49ª is 250 mm. in length. It has an axis 1 mm. in diameter and the rachis is 8 mm. in width. The leaves are much larger than in any specimen of *S. Sarsii* I have seen and bear 30 autozooids or more.

It seems to approach *S. veneris* in some respects but is too much damaged and broken to determine its affinities with certainty.

The arrangement of the spicules in the autozooids is very similar to that described by THOMSON and HENDERSON in *Sc. (P.) veneris* but the spicules are smaller, 0.02 mm. in length × 0.007 mm. in width. The spicules of the stalk are 0.03 mm. × 0.015 mm.

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The specimen from Station 204 is 120 mm. in length and appears to have affinities with *S. Martensii.*

The fragment from Station 105 also appears to be a Scytalium. There are numerous small granules of a reddish colour in the anthocodiae and these extend on to the back of the tentacles.

These granules are less than 0.01 mm. in diameter and do not have the characteristic form of Scytalium spicules. The specimen is so damaged that it is impossible to determine the number of autozooids and other characters.

Family Pteroeididae.

The family Pteroeididae corresponds with the sub-family Pteroidinae of Kölliker (1872), subsequently (1880) raised by him to the status of a family with the amended family name Pteroeididae.

Thomson and Henderson (1906 (2) p. 113) suggested a return to Kölliker's original plan of regarding the Pteroeididae as a sub-family of the Pennatulidae but I am in agreement with Balss (1910) and with Kükenthal and Broch (1911) in maintaining them as an independent family.

There were three genera in Kölliker's family: *Pteroeides, Godeffroyia* and *Sarcophyllum.* Of these three, *Godeffroyia* has disappeared from the family as a distinct genus, as Balss (1910 p. 60) has shown that it cannot be separated from *Pteroeides*, and its only species *G. elegans* becomes *Pteroeides Dofleini.*

In 1910, Broch proposed a new generic name for *Pteroeides caledonicum* and his genus *Struthiopteron* was accepted by Kükenthal and Broch (1911). I have given reasons however in this memoir (p. 241) for dissenting from this proposal and have replaced the species in the genus *Pteroeides.*

The genus *Gyrophyllum* (Studer 1901 p. 34), which found no definite resting place in the families recognised by Kükenthal and Broch, has, after further investigation, been assigned to the Pteroeididae in accordance with the original suggestion made by Studer (1901).

The family therefore now consists of the following three genera: —

Pteroeides Herklots.
Sarcophyllum Kölliker.
Gyrophyllum Studer.

The three genera are well defined and there can be no difficulty in distinguishing them. In *Pteroeides* the spicules of the leaves are always smooth needles the larger ones forming rays. The siphonozooids are arranged in plates (platte) on the underside of the leaves. There are no siphonozooids on the dorsal track but there are a few mesozooids at the upper end of the ventral track.

In *Sarcophyllum* the spicules of the leaves are smooth spicules, comparatively small in size, and do not form rays. The siphonozooids are confined to a swollen pad or ridge — the

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stipule — situated at the base of the dorsal edge of the leaf, and this pad may extend on to both its upper and lower surface (see p. 218). In addition to the siphonozooids, there is a row of zooids (Mesozooids) extending for some distance along the upper end of the middle line of the ventral track as in *Pteroeides*.

In *Gyrophyllum* the spicules of the leaves are 3-flanged rods which are not arranged in rays. The siphonozooids are distributed irregularly on both sides of the leaves and on the dorsal track and there are no mesozooids.

Pteroeides and *Sarcophyllum* are more closely related to each other than they are to *Gyrophyllum*. Their spicules are smooth needles without the ridges or flanges that are so characteristic of the spicules of *Pennatula*, *Gyrophyllum* and some other genera. They exhibit a similar row of mesozooids on the ventral track and have no siphonozooids on the dorsal track. They have a large swelling on the stalk just below the base of the rachis which is partly formed, by the development of a peculiar kind of spongy tissue below the cortex, and, according to the researches of KÖLLIKER (1872 p. 118), the anatomical structure of the stalk is very similar in the two genera. *Gyrophyllum* differs from them in the structure of the spicules, in the distribution of the siphonozooids and in the small number (7 to 8) of leaves on each side of the rachis. The swelling in the upper part of the stalk is not so pronounced as it is in *Sarcophyllum* and in many of the species of *Pteroeides*.

But, notwithstanding these differences, it is clear that *Gyrophyllum* is much more closely related to the Pteroeididae than it is to the Pennatulidae and I am of opinion that the affinities with the former are sufficient to justify its inclusion in the family. If it is included the diagnosis of the family must be modified to some extent and may read as follows: —

The family Pteroeididae includes Sea-pens with a thick fleshy rachis and stalk, and with large and usually thick leaves composed of a very large number of small autozooids. There are always siphonozooids on the leaves. The spicules are rod or needle shaped, smooth or 3-flanged.

The three genera may be arranged as follows: —

A. With spicular rays in the leaves . . . . . *Pteroeides*
B. Without spicular rays in the leaves
   1. With smooth spicules . . . . . *Sarcophyllum*
   2. With 3-flanged spicules. . . . . *Gyrophyllum*.

Geographical distribution. *Pteroeides* is cosmopolitan and confined to shallow water. *Sarcophyllum* has only been found off Australia and New Zealand in shallow water. *Gyrophyllum* has been found in the Atlantic Ocean and the Malay Archipelago in deep water.

Note on the siphonozooid pad or stipule of *Sarcophyllum*.

The arrangement of the siphonozooids in a group at the dorsal edge of the leaf is a very characteristic feature of the genus and one that is of great importance to the systematist as it enables him at once to distinguish *Sarcophyllum* from the only other genus with which it can be confused, namely *Leioptilum*. *Leioptilum* and *Sarcophyllum* are both thick fleshy sea-pens with large, kidney-shaped, closely set leaves, but they differ absolutely from each other in the arrangement of the siphonozooids and as well as in other characters.

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In *Leioptilum* there are numerous siphonozooids distributed over both sides of the dorsal track as in many species of *Pennatula*. In *Sarcophyllum* however they are confined to certain prominent ridges or pads at the dorsal edge of the leaves.

I have examined two specimens of *Sarcophyllum* from Australia, now in the Manchester Museum, and I take this opportunity to describe the arrangement of the siphonozooids in them as previous descriptions do not appear to me very clear and precise.

One of these specimens is 115 mm. in length and obviously a young form, the leaves being comparatively small and the tissues remarkably transparent. This specimen was briefly described by me (1890 p. 140) under the name *Sarcophyllum australe*. The name should have been *Sarcophyllum grande*. The other specimen is 185 mm. in length and much more typical in form.

In the larger specimen there is a thick, low, curved ridge extending from the dorsal edge of the leaf on to the dorsal track, and this ridge is covered with siphonozooids. There might be two interpretations of this ridge; either that it is an extension dorsally of the base of the leaf to carry the siphonozooids like the stipule of *Pteroeides caledonicum* or that it is a specialised thickened pad of the dorsal track itself. I have examined one of these ridges very carefully to see if any siphonozooids extend on to the surface of autozooid region of the leaf but so far as I could discover there are none. In the description of the species by KÜKENTHAL and BROCH (1911 p. 441) they say: "Der Zooidwulst findet sich an der dorsalen Blattkante des Kieles und greift ein wenig auf beide Blattseiten über". From this statement it seems probable therefore that the siphonozooids may extend beyond the stipule ("Zooidwulst" K. & B. or "Querwülste" Köll.) on to the true leaf.

In the smaller specimen, in which the siphonozooids can be much more clearly seen owing to the wonderful transparency of the tissues, the siphonozooids are arranged in a group or pad on the dorsal track opposite to the dorsal edge of each leaf. There is no visible ridge or pad connecting the group of siphonozooids with the edge of the leaf and the distance between the group and the leaf base is 1.5—2 mm.

Unless we accept the view that the siphonozooid pad of *Sarcophyllum* is homologous with the stipule of *Pteroeides caledonicum* and therefore in all probability an extension of the leaf, it would be quite erroneous to say that in this small specimen there are any siphonozooids on the leaf, but if the group of siphonozooids is on a part of the rachis which is destined as growth proceeds to give rise to the stipule portion of the leaf then in this specimen the siphonozooids are, from the morphological point of view, on the leaf and not on the dorsal track.

It might be thought that the young specimen is, perhaps, not a *Sarcophyllum* at all but a Pennatulid, but apart from the fact that the two specimens in our Museum were dredged off the same coast of Australia and apart from other anatomical characters, the fact that there is a row of mesozooids on the mid-ventral line of the rachis — a feature which, so far as I am aware, is only found in *Pteroeides* and *Sarcophyllum* — proves conclusively that the young specimen is a true *Sarcophyllum*.

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Genus **Pteroeides** Herklots.

Pteroeides Herklots 1858. Polypiers nageurs. p. 19, Pl. III.
Pteroeides + *Godeffroyia* Kölliker 1872. Die Pennatuliden. pp. 16 & 114.
Pteroeides + *Struthiopteron* Kükenthal & Broch 1911. "Valdivia" Pennatulacea. pp. 395 & 436.

The history of this genus has been fully discussed by NIEDERMEYER (1911) and by KÜKENTHAL and BROCH (1911). It is only necessary for me to add that for reasons given on p. 157 it is my opinion that the Sagitta marina nigra of RUMPHIUS (1705 p. 43) was a species of Pteroeides (probably *Pt. argenteum*) and not a species of Virgularia as KÖLLIKER supposed.

If this view is correct then the name of RUMPHIUS must be added to the list of the earlier writers to whom we owe a description of the genus. PALLAS (1766 p. 366) referred the Sagitta marina nigra of RUMPHIUS to the species "*Pennatula grandis*" but KÖLLIKER in 1872 on the ground that the specimen he examined came from the same spot (off the Castell Victoria at Amboyna) came to the conclusion that it was a Virgularia and gave to it the specific name *Virgularia Rumphii.*

As pointed out by NIEDERMEYER the first mention of the sea-pen now known as *Pteroeides griseum* is probably the reference to the "pennache du mer" by RONDELET in 1554 (p. 89) and it is of this common and widely distributed Mediterranean species that we have at the present day the best descriptive accounts.

Before passing on to the special anatomical features of the genus I must add that I am in agreement with modern writers in including in the genus Pteroeides, the following genera: — *Pteromorpha* of HERKLOTS, *Argentella* and *Crispella* of GRAY and *Godeffroyia* of KÖLLIKER. The genus *Struthiopteron* described by BROCH (1910 p. 64) was founded on a single very variable character which does not justify its retention. This genus is therefore also included in *Pteroeides.*

The principal distinguishing characters of the genus Pteroeides are: —

The arrangement of the larger spicules of the leaves to form a number of radiating bundles — the rays (Haupstrahlen) — which may project as a number of conical points or spines on the margin of the leaves giving them a cock's comb shape. The siphonozooids are arranged in a band or plate on the under side of the leaves, and there are one or more rows of mesozooids along the middle line of the upper part of the ventral track. There are no siphonozooids between the leaves nor on the dorsal track. The spicules are smooth spindles or needles, never ridged nor flanged.

The species included in the genus are usually short, fleshy sea-pens with large stout leaves. In the larger specimens of only one or two species (*Pteroeides argenteum*, *Pt. speciosum*) they can be described as long and slender.

The relative proportions of the different parts of the colony obviously afford characters that should be taken into consideration in the determination of species. Such forms as *Pt. argenteum*, *Pt. griseum* and *Pt. bankanense* differ from one another in superficial characters which can be recognised at once with the naked eye. But they are characters that must be used with the greatest caution as some species e.g. *Pt. caledonicum*, *Pt. malayense*, *Pt. sagamiense*,

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Pt. Esperi and others are very much alike in general form but differ from one another in more detailed structure.

As shown by the measurements of *Pt. malayense*, the ratio of length of rachis to length of stalk is in these very muscular sea-pens very variable when preserved specimens only can be measured.

Another ratio which may be regarded as of supplementary value is the ratio of length of rachis to breadth of rachis. The breadth of the rachis is measured by fixing a pair of the larger leaves, usually in the middle region, at right angles to the rachis and measuring the distance between their margins. It represents in most cases the dorsal margin of a large leaf $\times$ 2 + the width of the dorsal track. This ratio is of considerable value in some cases. There is for example a relationship between *Pteroeides malayense* and *Pteroeides Lacazii* in many structural details but the length-breadth ratio is decidedly greater in the latter than in the former and in this respect *Pteroeides malayense* is more closely related to *Pteroeides Esperi.*

Taking an average of nine specimens of each of 4 species I have found the ratio to be as follows: —

Pteroeides malayense	120 : 100
Pt. Esperi.	123 : 100
Pt. griseum.	140 : 100
Pt. Lacazii	226 : 100

The autozooids composing the leaves are very numerous, long and slender. They terminate distally in a zone which extends backwards from the margin of the leaf for a distance of a few millimetres. This zone of anthocodiae is usually confined to the under side of the leaf and is called the "autozooid zone" (Polypenzone) but in some species anthocodiae also occur on the upper side of the leaf.

In *P. malayense* the anthocodiae are equally distributed on both sides of the leaf and in the specimens I have described as *Pt. argenteum* there are almost as many anthocodiae on the upper side as on the lower but, according to other authors, the autozooid zone is usually on the under side.

The rays vary in number in the different species and show some variation within the range of a single species or individual. Each ray consists of a number of long smooth spicules arranged "en echelon" in long bundles which project to a greater or less extent beyond the margin of the leaves. Between the rays other spicules are found, the arrangement of which constitutes a character that may be used in the determination of species.

The arrangement of the siphonozooids on the leaves has been used by KÖLLIKER as the principal character for the separation of the species into groups. In some forms the siphonozooids form a narrow band or plate extending for a distance of 3 or 4 mm. from the base on the under side of the leaf. This arrangement is called "basal" (Pl. VIII, figs 49, 50, 52, 53). In others the siphonozooid plate lies in a position between the base and the margin of the leaf. This arrangement is called "median" (Pl. VIII, fig. 54). In others again the siphonozooid plate extends much further up the leaf, from the base, than in the first group and meets the autozooid zone. This arrangement is called "marginal". BALSS (1910) and KÜKENTHAL and BROCH (1911)

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declare that this character is subject to considerable variation and cannot be relied upon for the definite determination of species.

My own experience is that in some of the species I have examined it is almost constant. I have examined, for example, a very large number of leaves of the 13 specimens of *Pt. malayense* and found the siphonozooid plate, with one exception, to be "basal".

In *Pteroeides caledonicum* however the siphonozooid plate is much more variable (see p. 242) being in some cases technically basal, in others median and in others marginal.

Its position is obviously a character which is of use for specific distinction in some cases but may be misleading if used for grouping the species.

In the case of young or very young specimens it is a character that must be used with very great caution. We know so little about the development of Pennatulacean colonies that it would be hazardous to assert that a siphonozooid plate which begins as a median plate does not become either a basal plate or a marginal plate as the number of siphonozooids increases. As an example of this difficulty reference may be made to the young form (B) described on p. 250 which has a "median" plate of siphonozooids but in other respects appears to be related to a species in which the plate of the adult is basal.

The single exceptional case of a specimen of *Pteroeides malayense* with a marginal siphonozooid plate is of special interest (see p. 247). In this specimen the siphonozooid plate is much wider than it is in the other specimens, has a well marked serrate border and reaches the autozooid zone on the ventral side. This peculiarity is accompanied by another namely, the much wider autozooid zone on both sides of the leaf. Moreover the leaf is decidedly thicker and therefore more opaque than it is in the other specimens.

It seems probable that these characters are correlated. Although the number of autozooids is difficult to count it is quite certain that the number is greater in proportion to the size of the leaf than in the other specimens and the increase in the number not only increases the thickness of the leaf but necessitates an increase in the number of siphonozooids.

It would be interesting to learn whether in the development of the colony of other species, a siphonozooid plate which starts as a median becomes basal or a basal plate becomes marginal.

In *Pteroeides caledonicum*, a species with exceptionally wide leaves and a great many autozooids the siphonozooids extend on to a pad which projects on the dorsal track as a kind of supplementary leaf. These pads were called "Stielwülste" by KÖLLIKER and "Nebenblätter" by other german authorities. I propose to call them in this memoir the "stipules". The formation of stipules appears to be associated with an increase in the number of autozooids in the leaves and they afford an additional surface for the support of siphonozooids. The stipules usually have a jagged edge and are supported by three or four long spicules which in many cases project from the margin like the rays of the leaf. The siphonozooids are confined to the under side of the stipule (cf. the stipules of *Sarcophyllum* p. 217).

Although the stipules are larger and more constant in *Pt. caledonicum* than in any other species they are not confined to that species.

KÜKENTHAL and BROCH have already pointed out that KÖLLIKER (Pl. III, fig. 22) figures rudimentary stipules in *Pt. griseum*, but similar structures are also shown in his Plate VII,

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figure 60 of the Salatiga specimen of *Pteroeides Esperi* var. *latifolium*, and they also occur in the variety *augustifolium* of the same species if we may judge correctly from the following statement on p. 112: "An der unteren Blattseite geht die Zooidplatte mit einem besonderen, manchmal ganz getrennten Häufchen ventral bis an den Kiel". Moreover in the description of *Pt. robustum* Thomson and Simpson (1909 p. 292) say that there is a slight swelling or cushion at the prorachidial (i. e. dorsal) insertion of the leaf. There are also rudimentary stipules in some of the specimens of *Pt. hystrix* in the Leiden Museum.

The occurrence of stipules in *Pteroeides malayense* will be mentioned later, but this species shows great variations in this respect, the stipules being entirely absent in many specimens and in others well developed and provided with two or three projecting spicules. The specimen of *Pteroeides malayense* from Banda has an almost complete set of small stipules (Pl. V, fig. 34).

It will be seen therefore that the presence of stipules is a character that is not confined to one species and that, although it is apparently constant in *Pt. caledonicum*, it is not a character that can be relied upon to be constant in other species.

Of the other features of the leaves the most important are the size and arrangement of the spicules. In all the species of the genus a number of large rod or needle shaped spicules are arranged in radiating lines from the base to the margin of the leaf. These constitute the principal rays. The spicules of the rays are arranged one a little in advance of its neighbour, so that the ray may be two, three, or four spicules thick in any part of its course (Pl. VIII, fig. 51) according to the species. The terminal spicules of the rays may project beyond the margin of the leaf as well-marked spines giving the leaf "a cock's comb" appearance (Pl. VIII, fig. 50). The extent to which these spines project from the margin of the leaf cannot be used as a character for the determination of the species as it frequently exhibits great variation within the same species. For example KÖLLIKER (1872) described two varieties of his species *Pt. Lacazii*, one "spinosum" with the projecting spines and the other "molle" with rays that do not project at all, and in the species *Pteroeides griseum* of the Mediterranean there are also two varieties "brevispinosum" and "longispinosum" showing a considerable difference in the length of the spines.

The length of the spines may vary to some extent according to the mode of preservation, well preserved specimens which show the least shrinkage of the tissues having the shortest spines but it is also correlated with the number of autozooids and the thickness of the leaf. In specimens with very numerous and crowded autozooids the leaves are thicker and the spines do not project so far, as in leaves which have fewer autozooids and are thinner. This is very clearly seen in the series of specimens of *Pt. malayense* in the collection.

The number of rays varies, of course, with the position of the leaf on the rachis, the young small leaves at the base having fewer rays than the leaves in the middle of the rachis; but if the leaves in the middle of the rachis of a number of specimens be examined it will be found that the number of rays in a species does not show great variation (see table p. 245).

I am inclined to regard this character as one of the most important for specific determinations but it is one that must be used with some caution because in the species with thick leaves the number of rays cannot be determined with accuracy until the leaf is cleared in oil.

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In some species there is a very well marked differenee between the ray on the dorsal edge of the leaf and all the others. It is longer, thicker and built up of larger spicules. This is the case for example in *Pt. speciosum* (Köll.), *Pt. sagamiense* (Moroff) and *Pt. timorense* (Pl. VIII, fig. 52). The other rays spread out through the leaf from a point at the base of the strong dorsal ray in gradually diminishing strength towards the ventral side. The leaves of these species have a different shape to those of others being like a bird's wing or the blade of a scalpel, very thick on one side — the dorsal — and very thin on the other. In other species the number of rays is not very easy to determine as there are large spicules arranged in radial groups lying between the rays and these subsidiary rays may project from the margin as spines. This is the case for instance in the specimens of *Pteroeides argenteum*. These groups of spicules may form incomplete rays in some leaves and complete rays in others. The number of rays therefore varies considerably if only those groups of spicules are counted as rays which extend from the margin to the base.

Apart from the spicules constituting the rays, there are other spicules in the leaves of all the species I have examined, lying between the rays but they are very variable in number and arrangement. There are a few spicules quite as large as some of the ray spicules and others that are very much smaller. In some cases the smaller spicules are arranged parallel with and seem to support the anthocodiae in others they lie between the anthocodiae only. In some cases all these spicules are arranged radially in others they are more irregularly disposed.

The character of these intermediate spicules is so variable and shows so little difference in the examples of different species I have examined, that it cannot be regarded as of any value for specific distinction in those species.

Kükenthal and Broch (1911) have described and figured an arrangement of intermediate spicules in the leaves of *Pteroeides Jungerseni* (p. 421), *Pt. durum* (p. 426) and *Pt. bankanense* (p. 431) such as does not occur in any of the Siboga specimens, and it is possible that in these and other species the character may be less variable.

The spicules of the leaves of the genus *Pteroeides* are all of one type — long cylindrical spindles or needles without ridges. — They vary in size according to the size of the leaf and according to their position in the leaf and they frequently show abnormalities at one or both ends but I have not found any constant differences between a group of leaf spicules prepared from the leaf of one species and that from another.

When a leaf is cleared in oil of cloves and the spicules examined and measured with a micrometer there seems to be a marked difference between the big spicules of the rays and the small spicules between the rays, but when a whole leaf is boiled in potash and the spicules cleaned and mounted, a complete series can be found from the largest and thickest ray spicules to the smallest intermediate spicules.

Measurements of spicules that are made from pieces of a leaf that have been cleared in oil or from pieces of a leaf that have been boiled in potash and cleaned are apt to be misleading and give an erroneous impression that there are two kinds of spicules. With unique specimens the employment of one of these methods is perhaps the only legitimate course to adopt but when there are several specimens a whole leaf should be boiled and the spicules collected.

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In studying *Pt. malayense* the first set of measurements I obtained from a small piece of a leaf showed a wide gap between the large ray spicules (7—11 mm. in length) and the smaller spicules between the rays (0.5—1 mm. in length).

A series of about 200 spicules from a whole leaf completely filled this gap and showed moreover considerably more variation in the form of the spicules than was anticipated (Pl. VIII, fig. 78).

The largest spicule in this series was 14.5 mm. in length, 3.5 mm. longer than any spicules I had previously seen in the species, and from this downwards to minute spicules 0.5 mm. in length there was no break in the curve. In the matter of diameter there was considerable variation, decrease in length not being accompanied by a regular decrease in diameter.

The first spicule in the series 14.5 mm. in length had a maximum diameter of 0.3 mm., but the next one, of almost the same length was much more slender with a diameter not exceeding 0.25 mm. A spicule 10 mm. in length was 0.3 mm. in diameter; one of 5 mm. in length was 0.15 mm. in diameter, and one of 2 mm. in length 0.1 mm. in diameter.

In the larger spicules the diameter contracts at the ends to 0.15 mm. but at the actual extremities there was considerable variation. In some spicules both ends are pointed, in others one end pointed and the other slightly enlarged and rounded, in two specimens one end is flattened and rough, like the figure given by KÜKENTHAL and BROCH (p. 404) of the spicule of *Pteroeides griseum*.

In several spicules one end is marked by a number of irregular low ridges and spines running more or less parallel with the long axis and in some a low ridge runs along the surface for some distance in the middle and broadest part.

In comparing this series of spicules in *Pt. malayense* with those in other species similar variations were observed. Time and material prevented me from making such an elaborate investigation of the other species but the difference that could be observed was that in some species the spicules appeared to be on an average thicker or more slender than in others.

Thus the spicules of *Pt. caledonicum* appear to be more slender than in *Pt. malayense*. Typical examples of spicules in that species 14 mm. in length were 0.3 mm. in diameter, one of 13 mm. in length was 0.22 mm. in diameter. In *Pt. argenteum* the spicules are shorter and broader. Spicules 6 mm. in length were 0.25 mm. in diameter 3 mm. in length 0.12 mm. in diameter. In *Pt. timorense* the spicules are shorter and more slender. The largest spicules 5 mm. in length were 0.12 mm. in diameter and others 1 mm. in length were .09 mm. in diameter.

The spicules of the leaves, therefore, do not appear to me to afford very reliable characters for the determination of species. They are much too variable in the individual to give trustworthy evidence unless a very large series can be observed.

The spicules of the cortical layer of the stalk on the other hand are much more constant in the individual and afford one of the most valuable characters for the determination of species.

In *Pt. caledonicum* the spicules of the stalk are oval in outline, biconvex in section, and in the Siboga specimens about .047 × .013 mm. in size. Some may be a little larger and some a little smaller than this, but the general impression given by a cleared horizontal section

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of the stalk is that they are all of the same size (Textfig. 41). In *Pt. malayense* they have a spindle shape (0.172 × .013 mm.) but are variable as described below (Textfig. 41). In *Pt. argenteum* they are not very abundant and 0.87 × 0.07 mm. in size (Textfig. 40). In *Pt. timorense* they are very abundant and much larger, 1.39 × .07 mm. in size (Textfig. 40). In *Pt. speciosum* they are 1.5—2 mm. in length by 0.1 mm. in diameter and scattered (Textfig. 40).

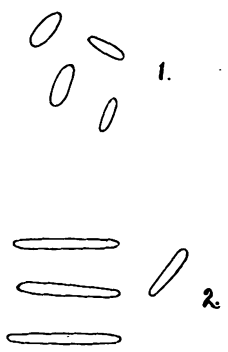

Fig. 41.
Spicules of the cortical layers of the stalk of
1. *Pt. caledonicum.*
2. *Pl. malayense.*
Both × 120 diam.

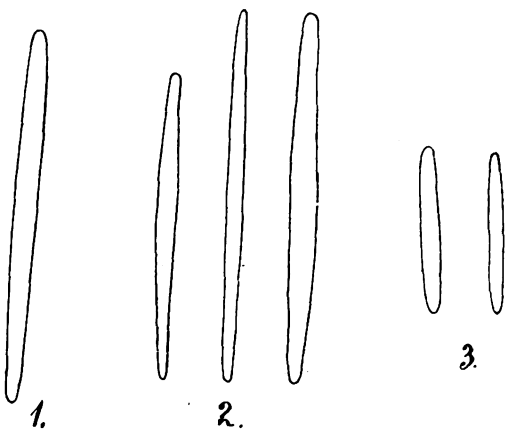

Fig. 40.
Spicules of the cortical layer of the stalk of
1. *Pt. speciosum.* 2. *Pt. timorense.* 3. *Pt. argenteum.*
All × 30 diam.

Nothing could be more striking than the difference between the stalk spicules of these species.

In order to test the variability of this character within the group of species, I have examined the stalk of six specimens of *Pt. malayense.* In one specimen that had been preserved in formol no spicules were found in the stalk, but I distrust formol preservation in the matter of spicules as an acid is sometimes developed which partly or wholly dissolves the calcareous substances. In the others a range of variation from a length of 0.17 mm. in a specimen from Stat. 79ª to 0.12 mm. in a specimen from Stat. 79 was observed and the spicules seemed to be more abundant in some forms than in others, but in all the specimens the spicules of the stalk were different from those of the other species.

The spicules of the inner parts of the stalk were not examined.

The peculiar zooids, now called mesozooids, on the upper part of the ventral track have been used for systematic purposes and there can be no doubt that they have a great value in this respect. In some species however, e. g. *Pt. malayense*, and *Pt. caledonicum* this character presents some difficulties, owing to the overlapping of the leaves on the ventral side and in some cases to the dark pigmentation of the skin. It is difficult to be certain how far this row of mesozooids extends without fully exposing the ventral track and this cannot always be done without injuring the leaves, and it is also difficult when the skin is deeply pigmented to be certain where precisely the row ends. In other species (e. g. *Pt. timorense*) when the ventral track is fully exposed and is transparent, the whole row can be seen without difficulty.

These mesozooids differ from the ordinary siphonozooids of the leaves in several particulars, as NIEDERMEYER (1911 p. 36) has clearly shown.

I have examined sections through these siphonozooids in *Pt. malayense* and I am able to confirm his results that they differ in 1. their greater size, 2. their calyx-like surface (in most cases but in others the calyx is absent), 3. the complete formation of mesenteries, 4. the presence of muscles on the mesenteries, 5. the weak siphonoglyph and 6. the straight course of the stomodaeum.

They were called "siphonozooids" by KÖLLIKER and other writers and "rachidiozooids"

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by NIEDERMEYER (1911) but as they are similar in structure to certain zooids found in *Pennatula Murrayi* and *P. grandis* I have called them mesozooids for reasons stated on p. 196.

The general anatomy of the Pteroeides colony has been described by KÖLLIKER (1872) and more recently by MUSGRAVE (1909) and NIEDERMEYER (1911 & 1912). One of the most important features of the anatomy, both from a systematic and physiological point of view, is the presence in the upper part of the stalk, of a remarkable "sphincter muscle" and this is accompanied by a great development of the oblique muscles of the stalk which are also found in some other Pennatulids (see MUSGRAVE p. 470 fig. 14).

The presence of the sphincter muscle may be a character that separates *Pteroeides* from other genera but it is of little use to the systematist until the anatomy of the other genera has been investigated. The great development of the muscular system of the stalk is however of importance when considering the value of the ratios of length of stalk and rachis.

The anatomy of *Pteroeides* is further distinguished by the great development of the "spongy tissue" between the principal canals and the body wall. This spongy tissue is extremely dense and tough and it is capable of becoming rigid and turgid by the absorption of liquids by its canals.

The great extent of this spongy tissue and the density of the muscular tissues of the stalk and rachis require an elaborate system for the circulation of fluids, and this circulation has been the subject of some interesting physiological investigations by MUSGRAVE (1909). The presence of a pore or pores at the base of the stalk has been denied by ELLIS and SOLANDER (1786), affirmed by O. F. MÜLLER (1788), by DELLA CHIAJE (1827) and by KÖLLIKER (1872), who found in some cases two pores at the base of the stalk in *Pteroeides* and *Pennatula*.

These pores are very difficult to observe even in sections of preserved specimens owing to the contraction of the tissues but, by her physiological experiments and observations of the living *Pteroeides griseum*, MUSGRAVE proved the existence of two pores at the base of the stalk, one communicating with the ventral longitudinal canal which is inhalent and one communicating with the dorsal longitudinal canal which is exhalent. In addition to these two, there are other pores near the base as well as four minute pores near the apex of the rachis and on its dorsal aspect which are functional as exhalent pores.

NIEDERMEYER (1911 and 1912) confirmed MUSGRAVE's results as regards the two main basal pores but both he and KÜKENTHAL and BROCH (1911 p. 539) regard the other exhalent pores described by MUSGRAVE as due to artificial rupture of the tissues.

Knowing well the care and skill with which Mrs MUSGRAVE's researches are conducted I have no doubt that her account is correct. Nevertheless it is quite possible that the secondary pores described by her are of a different morphological character to the two main pores, and like the cinclides and tentacle pores of many sea anemones, may be temporary and variable in number. There is no reason however to suppose that they are due to artificial rupture.

Variability and abnormalities.

Although the genus Pteroeides itself is fairly well defined there is, within its boundaries, a condition of variability which is most bewildering. All authors are agreed that it is the most

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difficult genus in the Order for the systematist and that the present position of affairs as regards the species is most unsatisfactory. The number of species that have been described as new is enormous and there is no scheme that in any way represents their true affinities. Several attempts have been made to reduce the number of species by fusion but even if we accept these attempts as satisfactory a very large number remain.

The descriptions of the best known species abound in statements with reference to their great variability. Thus KÖLLIKER (1872 p. 67) says of *Pteroeides griseum* (Bohadsch) "Die Variationen dieser Art sind zahlreicher als bei irgend einer andern Form, was z. Th. daher rühren mag, das dieselbe, weil unseren Meeren angehörend, viel häufiger gesammelt worden ist"; MARSHALL and FOWLER (1887 (2) p. 270) also comment on the great variability of the species *Pt. Lacazii* (Kölliker).

The more recent investigations of BALSS, confirmed in many respects by KÜKENTHAL and BROCH, show that the characters upon which the species are based are even more variable than KÖLLIKER supposed. Even the arrangement of the siphonozooids on the leaves and the rows of mesozooids on the ventral track are liable to variations and cannot be used for grouping the species as KÖLLIKER (1872) and THOMSON and SIMPSON (1909 p. 286) have done.

BALSS further considered that the thickness of the leaves depends so much upon the method of preservation that it cannot be depended upon for systematic purposes. KÜKENTHAL and BROCH however dissent from this view and maintain that the thickness of the leaves is an anatomical character dependent upon the development of spongy tissue and therefore may be used for the separation of species.

My own opinion is that, in the species I have examined, the thickness of the leaves is to some extent dependent on the method of preservation but that it is more definitely correlated with the number of autozooids in a given length of the margin of the leaf. The greater the number of autozooids or the wider the autozooid zone is, the thicker the leaf. I have not seen any spongy tissue in the leaf except at the base where it joins the rachis. In this respect my observations seem to be in agreement with those of KÖLLIKER who writes (1872 p. 32) "Gegen den Stiel der Fiederblätter zu liegt an beiden Flächen eine lage schwammigen Gewebes ähnlich demjenigen des Kieles".

Recognising the difficulty of basing a scheme of the species on any of these three characters, KÜKENTHAL and BROCH (1911 p. 398) arranged the species they investigated in a table based principally on skeletal structures.

This table does not appear to me to be an improvement on those that have preceded it because the principal character used appears to be much too variable for the purpose.

These authors divide their species into two main groups with the following characters.

Group I Polypenzone mit vielen grossen und kleinen Spicula von welchen die grösseren in mehr oder weniger regelmässigen Zügen angeordnet sind.

Group II Polypenzone nur mit einer Sorte kleiner, stabförmiger Spicula oder mit äusserst wenigen Spicula einer oder beider Sorten.

In my investigations of *Pt. malayense* I found the spicules of the autozooid zone so very variable that it was difficult to determine whether the species belonged to KÜKENTHAL's Group I

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or Group II. In some leaves they have an arrangement like that of *Pt. griseum* (forma *brevispinosa*) belonging to Group I and in others more like that of *Pt. Lacazii* belonging to Group II.

BALSS (1910 p. 64) has also pointed out that in *Pteroeides sagamiense* the armature of spicules in the leaves is very variable, the spicules being in some cases very numerous and in others sparcely distributed. The primary grouping of the species according to KÜKENTHAL and BROCH's scheme therefore appears to me unsound and, even if, in other species than those I have had the opportunity of investigating, the characters on which it is based is less variable, it is a grouping which I believe systematists will find very difficult in application.

A summary of the characters that can be made use of for the division into species of the genus *Pteroeides* shows, then, that they are all variable and that no single one can be relied upon for an absolute diagnosis. The characters that appear to me to be the least variable and the most useful from a practical as well as a scientific point of view are: —

1. The arrangement of the rays in the leaf and the number of the rays.
2. The character and size of the spicules of the cortical layer of the stalk (Stielrinde).
3. The number of leaves.
4. The ratio between width and length of the rachis.

The last two characters cannot be used with confidence unless the specimens are nearly or quite full grown.

The extreme variability of the characters of Pteroeides, although it increases enormously the labours of the systematist, is really a feature of great theoretical interest. It shows that a colony which has acquired a very decided bilateral symmetry and an elaborate muscular system for purposes of locomotion may still retain a very great measure of adaptability to external conditions and variation in many directions.

It may be difficult, at present, to prove that any particular line of variation is an adaptation to the condition of a locality, the correlate depth or temperature with spicular armament, or thickness of the leaves; or to suggest a reason for the prevalence of certain forms in some localities and their absence in others but the great plasticity or power of variation that the genus exhibits is in itself a character of no little importance and must take its place among the others whenever the genus is described in detail.

Associated with ordinary variations are the so called abnormalities to which we find many references in the literature. For example MARSHALL and FOWLER (1887) in their description of specimens of *Pteroeides Lacazii* from the Mergui Archipelago call attention to the formation of additional leaves on the dorsal track. "On the left side there is an incomplete row of isolated autozooids and on the right side two large irregular leaves with siphonozooids plates". BALSS also mentions the occurrence of two large (3 mm. long) isolated autozooids surrounded at the base by small siphonozooids on the dorsal track of a specimen of *Pteroeides Dofleini*.

NIEDERMEYER (1911 p. 33) gives an account of an interesting abnormality in a specimen of *Pteroeides griseum* in which two fully developed leaves were fused along their outer margins leading to an inversion of the surfaces of one of the leaves.

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In one specimen of *Pteroeides malayense* from Stat. 79ª (Pl. V, fig. 33 *A*) there are two examples of what look like isolated autozooids standing on the dorsal track at a distance of about 2 mm. from the leaves. On microscopic examination of one of them it was found to consist of two autozooids with a single row of long spicules and a little group of siphonozooids at the base.

But a commoner form of abnormality of which I have observed six cases in the same species is that a deep split occurs in a leaf extending from the margin to the base which isolates so much of the leaf as is supported by two or three rays. When this occurs on the right side a similar abnormality usually is found in the corresponding leaf on the left side.

Arrangement of the species.

In a genus like *Pteroeides* which is subject to so much variation in every particular character, any arrangement of the species must be regarded as purely provisional, but for the convenience of those whose duty it is to name specimens obtained by collectors an attempt should be made to arrange the species that have been described in some kind of order.

For this purpose it is best that the arrangement, if possible, should be based on characters that can be studied without the dissection or mutilation of the specimens, and on characters that have been described by authors in their description of the type. It is also of importance that the arrangement should follow a plan which is based on conceivable lines of evolution so that the grouping of the species may represent as far as possible natural groups of species.

The arrangement that is suggested in the following pages is based on the supposition that in the most primitive type of the genus there were numerous spicules in the leaf arranged more or less irregularly, so that no definite rays were formed. This type is represented by only one species *Pt. nigrum* (Division A) (Pl. X, fig. 76). From this primitive type there were two lines of descent one in which definite rays were formed increasing in number with the size and complexity of the leaf (Division B) and the other in which the spicules primarily concentrated themselves on the more exposed dorsal edge of the leaf and were supplemented by an increasing number of secondary rays of lower intensity (Division C).

The sub-division of Division B which contains the greatest number of species, may be based arbitrarily on the number of rays and I propose the constitution of three groups; those with less than 10 rays, those with between 10 and 20 rays and those with more than 20 rays.

It was found by examination of a considerable number of specimens of *Pt. malayense* from the same locality that the number of rays of the leaves in the middle of the rachis is remarkably constant but the number diminishes in the leaves at the distal end and at the proximal ends.

This grouping depends then upon the number of rays in the middle region of the rachis only. Moreover, it is applicable only to specimens that may be regarded as full grown or almost full grown.

The determination of what is or is not a full grown specimen is, in the present state of our knowledge an extremely difficult matter. The presence or absence of gonads is no guide, as it seems perfectly certain that all Pennatulids become sexually mature long before they attain to their full size, and the only guide we have for the determination of many of the young

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forms of say 50 mm. or less in length is their geographical association with larger specimens.

This sub-division into groups will doubtless need some modification and may involve some overlapping. The species *Pt. bankanense* for example has according to KÜKENTHAL and BROCH 8—24 rays and should therefore appear in all three groups; but some cases of overlapping must occur in any system that can be suggested and they only act as warning to systematists that the arrangement is at best artificial.

The sub-division of the groups is based on the character of the siphonozooid plate and on the length-breadth ratio of the rachis.

The position of the siphonozooid plate is, as BALSS, and KÜKENTHAL have maintained, a variable character. In some species, such as *Pt. caledonicum* it is difficult of interpretation but, in my experience it is usually a fairly reliable character. The length-breadth ratio of the rachis although liable to some variation, affords a better character for classification in the genus Pteroeides than the ratio of the length of the rachis to the length of the stalk.

It is unfortunate that the character and size of the spicules in the cortical layer of the stalk cannot be used, at present, in a systematic survey of the species. It is a character which will probably be found to be of the greatest value but we have no information about these spicules in most of the species that have been described. It is not claimed that the arrangement here proposed is perfect or final but I may express my hope that it my be found useful when used in conjunction with the schemes of KÖLLIKER and of KÜKENTHAL and BROCH.

In the following tables, the asterisk *, after a specific name signifies that only one specimen of the species has been described and the dagger † signifies that the single specimen was probably a young form. I regard all the species thus marked as doubtful species. The species in italics were founded on badly preserved type specimens and should not be recognised.

DIVISION A. Without definite rays.

Leaves with a large number of spicules but no well defined rays.

Pt. nigrum Köll.

One specimen described by KÖLLIKER (1872 p. 51) loc. incert. one by THOMSON and SIMPSON (1909), Indian Ocean and one (doubtful) by HICKSON, Malay Archipelago.

DIVISION B. With rays of approximately equal intensity.

Group I. *Species with less than 10 rays.*

Pt. andamanense. Th. & S.
„ argenteum. E. & S.
„ Dübenii. Köll. 1872.
„ *elegans*. Herkl. *
„ Hartingii. Köll. * 1872.
Pt. Jungerseni. Broch * † (1910).
„ lusitanicum. Broch 1910.
„ pulchellum. Th. & H. * † 1906 (1).
„ rigidum. Th. & H. 1906 (1).
„ *Westermanni*. Köll. * 1872.

Of the species with less than 10 rays the following have a rachis more than twice as long as it is broad: —

Pt. argenteum.
„ elegans.
Pt. pulchellum.
„ rigidum.

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With a rachis twice as long as it is broad: —

Pt. Dübenii
„ Hartingii.
„ Jungerseni.
Pt. lusitanicum.
„ Westermanni.

With a rachis $1^1/_2$ times as long as it is broad: —

Pt. andamanense.

Group II. *The following species have from 10—20 rays.*

Pt. acuminatum. Köll. * 1872.
„ aurantiacum. Bleek. *
„ *bankanense*. Bleek.
„ *Bleekerii*. Köll. * 1872.
„ brachycaulon. Köll. * † 1872.
„ breve. Köll. * † 1872.
„ caledonicum. Köll. 1872.
„ chinense. Herkl.
„ durum. Köll. 1872.
„ Esperi. Herkl.
„ *ferrugineum*. Köll. * 1872.
„ flavidum. Köll. 1872.
„ fusconotatum. Köll. * 1872.
„ gracile. Köll. * † 1872.
„ griseum. Boh.
„ hydropicum Cuv. *
„ *hymenocaulon*. Bleek.
Pt. ilicifolium. Th. & S. *
„ indicum. Th. & S. *
„ intermedium. Th. & S.
„ isosceles. Thomson * 1915.
„ japonicum. Herkl. *
„ Lacazii. Köll. 1872.
„ latepinnatum. Herkl. *
„ malayense. Hick.
„ manillense. Köll. *
„ Pagenstecheri. Pfeff. *
„ pellucidum Köll. *
„ punctatum. Th. & S.
„ robustum. Th. & S.
„ sarcocaulon. Bleek.
„ *Schlegelii*. Köll. * 1872.
„ tenerum Köll. 1872.

Species with 10—20 rays, may be divided into 3 groups.

1. With a marginal siphonozooid plate.

Pt. acuminatum.
„ aurantiacum.
„ bankanense.
„ Bleekerii.
Pt. chinense.
„ durum.
„ Esperi.
„ ferrugineum.
Pt. flavidum.
„ fusconotatum.
„ hydropicum.
„ hymenocaulon.
Pt. japonicum.
„ latepinnatum.
„ sarcocaulon.
„ tenerum.

2. With a median siphonozooid plate.

Pt. caledonicum.
„ brachycaulon.
„ breve.
Pt. gracile.
„ indicum.
„ isosceles.
Pt. manillense.
„ pellucidum.
„ punctatum.

3. With a basal siphonozooid plate.

Pt. griseum.
„ ilicifolium.
Pt. intermedium.
„ Lacazii.
Pt. malayense.
„ Pagenstecheri.
Pt. robustum.
„ Schlegelii.

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Species with 10—20 rays and a marginal siphonozooid plate may be divided into 3 groups.

1. Rachis twice as long as broad.

Pt. aurantiacum.
„ Bleekerii.
Pt. durum.

2. Rachis 1.5 times as long as it is broad.

Pt. acuminatum.
„ ferrugineum.
„ fusconotatum.
Pt. hymenocaulon.
„ japonicum.
„ latepinnatum.
Pt. tenerum.

3. Rachis the same length as breadth.

Pt. bankanense.
„ chinense.
„ Esperi.
Pt. flavidum.
„ hydropicum.

Species with 10—20 rays and a median siphonozooid plate.

1. With rachis twice as long as broad.

Pt. brachycaulon.

2. With rachis 1.5 times as long as broad.

Pt. caledonicum.
„ gracile.
„ indicum.
Pt. isosceles.
„ manillense.
„ pellucidum.
Pt. punctatum.

3. With rachis the same length as breadth.

Pt. breve.

Species with 10—20 rays and basal siphonozooid plate.

1. Rachis longer than it is broad.

Pt. Lacazii.
„ Schlegelii.
Pt. Pagenstecheri.
„ ilicifolium.

2. With rachis the same length as breadth.

Pt. griseum.
„ intermedium.
Pt. malayense.
„ robustum.

Group 3. *Species with over 20 rays.*

Pt. breviradiatum. Köll. 1872.
„ carduus. Val. *
„ crassum. Köll. 1872.
„ Herklotsii. Köll. * 1872.
„ hystrix. Köll. 1872.
„ imbricatum. Köll. * 1872.
Pt. javanicum Bleek.
„ latissimum. Köll. 1872.
„ lugubre. Köll. * 1872.
„ multiradiatum. Köll. 1872.
„ Sparmannii. Köll. 1872.
„ Steenstrupii. Köll. 1872.

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Species with over 20 rays.

All these species have marginal siphonozooid plates with the exception of *Pt. hystrix* and *Pt. multiradiatum* in which the siphonozooid plate is basal.

In the following species the rachis is twice or more than twice as long as it is broad:
Pt. multiradiatum.

In the following it is 1.5 times as long as broad: Pt. Steenstrupii.

In the following it is as long it is as broad: —

Pt. breviradiatum. Pt. Herklotsii. Pt. javanicum. Pt. lugubre.
„ carduus. „ hystrix. „ latissimum. „ Sparmannii.

In the following it is broader than long: P. imbricatum.

Division C.

Species with a very strongly developed dorsal ray. The "Sagamiense" group of Kükenthal and Broch.

Pt. Dofleini Balss 1910.
„ Macandrewi Köll. 1872.
„ sagamiense Moroff.
Pt. speciosum Köll. 1872.
„ timorense Hickson. * †.
„ triradiatum Th. & H. 1906 (2).

Of these species:

Pt. Dofleini = Godeffroyia elegans Köll. 1872, has only the single strong dorsal ray.
„ radiatum has 3 rays.
„ speciosum has 4—6 rays.
„ timorense has 6—7 rays.
„ Macandrewi has 7—9 rays.
„ sagamiense has many rays in addition to the very strong dorsal ray.

Synonyms. If we accept the identification of the older species made by Kölliker, the most important suggestions for the amalgamation of species are those made by Kükenthal and Broch.

According to these authors.

Pt. rhomboidale Moroff, Pt. heteroradiatum Broch = Pt. sagamiense Moroff.
Pt. Pagenstecheri Pfeffer = Pt. Lacazii Köll.
Pt. chinense Herk., Pt. lugubre Köll. = Pt. bankanense Bleek.
Godeffroyia elegans Köll. = Pt. Dofleini Balss.

Having examined the type specimens of the following species and found them to be badly preserved, I am of opinion that they should no longer be recognised. The specimens seem to have been immersed in an acid for some time, as the spicules are quite soft and flexible, and in some of them the margins of the leaves are destroyed or imperfect:

Pt. bankanense. Pt. elegans. Pt. hymenocaulon. Pt. Westermanni.
„ Bleekerii. „ ferrugineum. „ Schlegelii.

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The species of the genus *Pteroeides* from the Malay Archipelago.

Two new species of the genus have been described in this Memoir, *Pt. malayense* and *Pt. timorense*. The latter is represented by one small specimen and may be regarded as provisional. The former, represented by 17 specimens differs, in some important particulars from the descriptions given of all the 14 species hitherto described from the waters of the Malay Archipelago that are given in the following list.

It is very probable that further investigations of these 14 species would render some amalgamation of species a necessity and that *Pt. malayense* will eventually be fused with one of the older ones but for the present it cannot be determined to which of these species it should be joined.

Species of Pteroeides from the Malay Archipelago mentioned by KÖLLIKER (1872) (with one exception), and the Museums in which the type specimens are preserved.

East Indies	Pt. argenteum	Amsterdam Museum
Amboyna	„ aurantiacum	Leiden „
„	„ caledonicum	British „
„	„ hymenocaulon	Leiden „
„	„ speciosum?. see p. 237.	Leiden „
„	„ Lacazii	(fide MOROFF)
Banka	„ bankanense	Leiden „
„	„ chinense	British „
E. Borneo	„ sarcocaulon	Leiden „
Java	„ Steenstrupii	Copenhagen „
„	„ Esperi (3)	Leiden „
„	„ ferrugineum	Leiden „
„	„ flavidum	Amsterdam „
„	„ hydropicum	Paris „
„	„ javanicum (6)	Leiden „
Sumatra	„ Esperi	Leiden „
„	„ Lacazii	Paris „

Of these species

Pt. argenteum *Pt. Lacazii.*
Pt. caledonicum *Pt. chinense.*

are quite distinct and can be easily recognised.

Pt. timorense, a species founded on one specimen, appears to be quite distinct, but may not prove to be a good species.

The remaining species overlap one another and appear to be closely related. It is very probable that they represent local varieties of one very variable species but I do not consider that our knowledge of the variability of species is sufficiently advanced to justify at present any proposal to amalgamate them into one species. Nevertheless, some reduction of the number

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can be made without hesitation and thereby the systematic study of the study be considerably simplified.

Five species can be struck out on the ground that the type specimens are so badly preserved that identification with them is impossible namely: *Pt. hymenocaulon*, *Pt. bankanense*, *Pt. sarcocaulon*, *Pt. ferrugineum* and *Pt. flavidum*.

I have carefully compared the specimen of *Pt. aurantiacum* described by KÖLLIKER with the specimens of *Pt. javanicum* in the Leiden Museum and have found small spicules in the autozooid zone between the rays in both species and I am convinced that they are in all essential respects identical.

I have not seen the type specimen of *Pteroeides hydropicum* but judging from the description given by KÖLLIKER it must be closely allied to *Pt. Esperi* a species that has been obtained in the same seas. As the date of the label on which the name *Pt. hydropicum* was written in not known, the name of the amalgamated species should *Pt. Esperi* Herklots.

Pteroeides Steenstrupii and *Pt. malayense* should in my opinion, be retained as distinct species for the present.

In addition to the species mentioned in the list given above it is very probable that the specimens of *Pteroeides hystrix* in the Dutch museums also came from the Malay Archipelago and it might be convenient to consider them in this place as probably Malayan forms. The same may be said for the single specimen of *P. tenerum* in the Amsterdam Museum.

Pteroeides hystrix may provisionally be regarded as distinct, the large number of projecting rays forming a very well defined character. *Pt. tenerum* I regard as identical with *Pt. Esperi*.

These species may be arranged as follows: —

A. With a rachis three times or more than three times as long as it is broad.
   1. With a strongly developed dorsal ray, particularly in the lower leaves — *Pt. speciosum*
   2. With no strongly developed dorsal ray in the lower leaves . . . — *Pt. argenteum*

B. With a rachis one and a half to twice as long as it is broad.
   1. With a strongly developed dorsal ray on the leaves . . . . . — *Pt. timorense*
   2. Without a strongly developed dorsal ray on the leaves . . . . — *Pt. Lacazii*

C. With a rachis about as long as it is broad.
   1. With well-developed stipules at the base of all the leaves . . . — *Pt. caledonicum.*
   2. Without stipules or with feebly developed stipules at the base of some of the leaves
      a. With marginal siphonozooid plates . . . . . — *Pt. aurantiacum*, *Pt. Steenstrupii*, *Pt. Esperi*
      b. With basal siphonozooid plates. . . . . — *Pt. hystrix*, *Pt. malayense*

D. With a rachis broader than it is long and a short stalk. . . . . — *Pt. chinense.*

To these may be added with some doubt *Pt. nigrum* a long narrow sea-pen without any clearly defined rays in the leaves.

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1. *Pteroeides nigrum* Kölliker. (Pl X, fig. 76).

? *Pteroeides nigrum* Kölliker 1872. Die Pennatuliden. p. 56, no fig.

Stat. 231. Amboyna Anchorage. 40 metres. 1 Ex.

There is a single, very damaged specimen from the Amboyna Anchorage, which must be provisionally placed in this species.

The rachis is very much contracted and it is dragged off the axis for a distance of about one half its total length. From the base of the rachis the axis projects for a length of 210 mm. The stalk is entirely missing.

The rachis, in its contracted condition, is 80 mm. in length and its greatest breadth is 12 mm.

The leaves are small and in the middle of the rachis almost square in shape, with a dorsal margin of 5 mm. and a width of 5 mm.

The leaves are supported by a thick mass of long broad spicules with two indistinct gaps and by numerous smaller spicules of various lengths. Only a few of the larger spicules project beyond the margin of the leaf (Pl. X, fig. 76).

The leaf may be interpreted either to have no clearly defined rays (ohne deutliche Hauptstrahlen) or to have three very broad rays separated by ill-defined gaps.

The autozooid zone is rather broad and the siphonozooid plate is basal. The exposed part of the axis is cylindrical in shape with a maximum diameter of 2 mm. and it is dark slate blue in colour. The leaves and rachis have also a dark slate blue colour in patches.

The specimen was so much damaged that it seemed hardly worth while to record it or describe it in detail, but as it evidently belongs to one of the species with a long narrow rachis and has a dark coloured axis and was found at Amboyna it may possibly be the pennatulid described by Rumphius as Sagitta marina nigra.

2. *Pteroeides speciosum* Kölliker. (Pl. VIII, fig. 52 and Textfig. 40).

Pteroeides speciosum Kölliker 1872. Die Pennatuliden. p. 54, Pl. III, fig. 13.

Stat. 51. Molo Strait. 69—91 metres. 1 Ex. (imperfect).

This specimen from which the greater part of the rachis appears to be missing approaches most nearly to the description of Kölliker's *Pteroeides speciosum* from an unknown locality (Amsterdam Museum). Only 40 mm. of the length of the rachis remain and from the distal end the axis projects for a distance of 10 mm. It is unfortunately impossible to hazard a guess as to how much of the rachis has been lost.

The width of the rachis is 22 mm. and of the dorsal track 7.5 mm. The leaves are fan-shaped, 25 in number on each side, with an insertion of 3.5 mm. and a width of margin of 13.5 mm.

The length of the thick dorsal ray is 12 mm. There is a wide autozooid zone 3 mm. in

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width at the dorsal edge and a plate of siphonozooids extending from the base to a distance in some places of 3 mm. along the under surface of the leaf (Plate VIII, fig. 52).

There is a very thick dorsal ray (DR. in the figure) composed of large spicules three or four abreast and from the base of this four other rays radiate each composed of two or rarely, three spicules abreast. Some of the rays project from the margin as single spicule spines, but there are in addition some spines at the margin formed by single spicules which do not correspond with the rays. The longest ray spicules are 7.25 mm. in length. Between the rays small spicules from 0.6 mm. in length to minute rods are scattered.

The stalk is 120 mm. in length (i. e. three times the length of the remnant of the rachis) cylindrical in shape and about 4 mm. in diameter. It is badly ruptured at the base. Just below the surface there are several large spicules from 1.5—2 mm. in length and about 0.1 mm. in diameter arranged parallel with one another and with the axis (Textfig. 40 p. 225). The part of the axis that is exposed at the distal end is cylindrical 2 mm. in diameter and brown (in colour).

KÖLLIKER (1872 pp. 55 and 56) attributed two specimens to this species; the type specimen in the Amsterdam Museum from an unknown locality and a second specimen in the Leiden Museum from Amboyna.

The specimen from Molo Strait is clearly identical with the type of the species, and the type is quite distinct from *Pteroeides argenteum* The specimen in the Leiden Museum is quite different to the type and appears to me to belong to a distinct species. KÖLLIKER has himself clearly pointed out some of these differences but there is one difference which is of critical importance that he does not refer to.

In the type specimen, on passing downwards from the middle region of the rachis to the base, all the rays except the great dorsal ray diminish in size and importance until only the great dorsal ray and a few odd spicules are left. The small lower leaves are shaped like the blade of a scapula with the dorsal edge supported by a thick band of spicules.

In the specimen from Amboyna in the Leiden Museum, all the rays including the dorsal ray diminish in size regularly, so that the basal leaves exhibit a number of small or rudimentary rays of approximately equal size. In the larger leaves of this specimen the dorsal ray of some of the leaves is larger than the others and composite in character, but I have observed this feature also in some of the specimens of *Pteroeides argenteum*.

The second specimen of KÖLLIKER is not therefore a true *Pteroeides speciosum* but is probably more closely related to, if not identical with, *Pteroeides argenteum*.

A description of a young Pteroeides that may belong to this species is given on p. 250.

3. *Pteroeides argenteum* Ellis and Solander. (Plate VIII, figs 50 & 51; Textfig. 40 & 42).

Pennatula grandis Pallas 1766. Elenchus zoophytorum. p. 366.
Pennatula argentea Ellis & Solander 1786. Zoophytes. p. 66, Pl. VIII.
Pteroeides grande Herklots 1858. Polypiers nageurs. p. 21, Pl. VI.
Pteroeides argenteum Kölliker 1872. Die Pennatuliden. p. 52.

New Guinea Expedition 1903. Humboldt Bay. 2 Ex.

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The two specimens from New Guinea, sent to me with the Siboga material, are much smaller than any of the specimens of the species hitherto described.

HERKLOTS gives the length of his specimens as 400 mm. KÖLLIKER's specimens were 278, 308 and 425 mm. respectively. The two specimens from Humboldt bay were 175 mm. and 110 mm. In proportion to the length of the rachis, the width is much greater in these specimens than in those previously described. According to KÖLLIKER's measurements the ratio of width to length of rachis is 10 : 75, 10 : 45 and 10 : 95, according to HERKLOTS' figures 10 : 66 and according to ELLIS and SOLANDER 10 : 55. In our specimens the ratios are 10 : 30 and 10 : 22.

Apart from this difference which I think may be accounted for by age, the specimens are in general agreement with the descriptions of the type.

The principal measurements of the two specimens are: —

	A	B
Total length	175 mm.	110 mm.
Length of rachis	110 „	65 „
Length of stalk	65 „	45 „
Width of rachis	37 „	28 „
Width of dorsal track	7 „	7 „
Diameter of stalk in region of sphincter	12 „	8 „
Diameter of middle region of stalk	10 „	6 „
Number of leaves	47, 46	?

In these comparatively slender sea-pens, the leaves are short and overlapping, meeting on the ventral side for a distance of about two-thirds of the total length of the rachis.

The dorsal margin of the larger leaves is 10—12 mm. in length, and it is of interest to note that this measurement is somewhat less than the "longueur d'une pinnule" given by HERKLOTS as 15 mm. in a much larger specimen.

The lower leaves are only slightly inclined towards the dorsal side.

The leaves are comparatively thick and the principal rays project very little beyond the margin, so that the term "serrate" would be more appropriate to describe the edge than "spinous" (Plate VIII, fig. 50).

There are 10 principal rays in the larger leaves but the number is much more variable than it is in other species. The number is much greater than that given by KÖLLIKER for the species but there may be some uncertainty as to the way in which KÖLLIKER counted the rays and possibly the descrepancy is not so great as it appears. The leaf has a very close resemblance to the figure given by ELLIS and SOLANDER (1786 Pl. VIII) and, on the strength of that, the identification may be regarded as correct.

The principal rays are formed by stout spicules arranged "en echelon" so that three or four spicules constitute the breadth of the ray at any one spot (Plate VIII, fig. 51).

These spicules are from 4—5 mm. in length with a diameter of 0.36 mm.

Between the rays a few shorter and thinner spicules from 2—0.5 mm. in length, arranged parallel with the rays and some on the calices of the autozooids, are scattered about on the

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upper surface of the leaf, but in one or two places a larger spicule or two occur between the principal rays and project from the edge like rudimentary rays.

The autozooid zone is very broad, having a width of about 4 mm.

The siphonozooid plate is basal but not very narrow.

A peculiarity of these leaves which I have not noticed in other species, is the presence of a number of coecal canals at the edge of the leaf (Textfig. 42 *c. c.*) accompanying the larger spicules. They can be best seen in a leaf that has been cleared in oil of cloves.

The calices of the autozooids are comparatively long and cylindrical.

The dorsal track is fully exposed and has almost parallel sides for the greater part of its length. The ventral track which is very much hidden by the overhanging leaves bears a single long row of mesozooids.

The stalk is long and cylindrical with a slight swelling in the region of the sphincter muscle. The spicules in the cortical layer are not very abundant but of good size (0.87 × .07 mm.) (Textfig. 40, 3. p. 225).

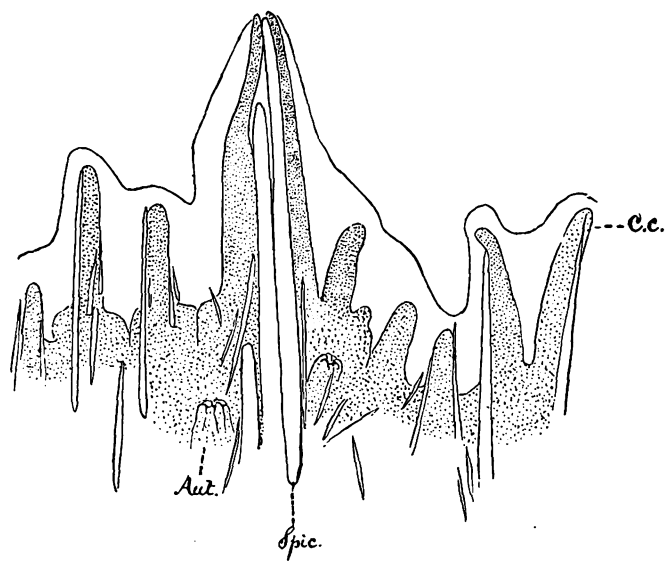

Fig. 42.
A portion of the edge of the leaf of *Pteroeides argenteum*, showing the coecal canals *c. c.* of endoderm that accompany the spicules.

Colour. The stalk and ventral track of Spec. A are straw-coloured, the leaves of the same colour but mottled with pale slate coloured patches. The dorsal track is slate coloured with a few patches of yellow. The smaller specimen (B) has the same general arrangement of colour but the leaves are more profusely mottled with slate-colour and the dorsal track is almost continuously slate-coloured.

The axis. Only a very short portion of the axis in the region of the stalk was exposed in one specimen. It was cylindrical in shape and brown in colour.

The specimen of *Pteroeides argenteum durissimum* in the Amsterdam Museum described by KÖLLIKER (1872 p. 54) the largest known specimen is not very well preserved the edges of the leaves being worn and the exact arrangement of the siphonozooid plate on many of the leaves very difficult to determine.

The leaves are closely pressed against the sides of the rachis and in this position the breadth of the rachis corresponds with the figure (26 mm.) given by KÖLLIKER but when the rays are fixed in the position which we may regard as the more natural one at right angles to the rachis, the breadth of the rachis may be calculated to be 35 mm. This reduces KÖLLIKER's width to length ratio of the rachis of this specimen from 10 : 94 to 10 : 64.

It has evidently a narrower rachis in proportion to its length than the specimens described above from Humboldt bay but this may be correlated with its greater size and age.

I have also examined the two smaller specimens of the typical form of the species in

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the Amsterdam Museum referred to by KÖLLIKER (1872 p. 53) and another more recently collected by Dr. SLUITER off Billiton Island.

Dr. SLUITER's specimen is 180 mm. in total length and has a width to length ratio of the rachis of 10 : 47.

In this specimen as in the smaller of the two older specimens the coecal canals on the edges of the leaves described above (p. 239) can be clearly seen. I have not seen these processes in any other species of the genus I have examined.

All these specimens have a brown axis.

3. *Pteroeides timorense* n. sp. (Pl. V, fig. 35; Pl. VIII fig. 49 & textfig. 40 p. 225).

Stat. 294. 10° 12′ S., 124° 17′ E. S. coast of Timor. 73 metres. 1 Ex.

The single specimen from this locality does not agree with the description of any named species. It may have affinities with KÖLLIKER's "hymenocaulon" group and particularly with his species *Pteroeides hydropicum* founded on a single specimen in the Paris Museum from Java. It differs from this species however in the smaller number of leaves, the smaller number of rays and in the arrangement of the siphonozooids.

It is possible that it is a young form of one of the larger species such as *Pteroeides argenteum* or *Pt. speciosum* but until we have further information concerning the development of these species it must be separated from them as a distinct species.

The total length of the specimen is 116 mm. and the length of the rachis 60 mm. of the stalk 56 mm., the greatest breadth of the rachis is 40 mm., the width of the dorsal track 11 mm. and the diameter of the stalk 5 mm.

There are 17 large leaves and 5 or 7 rudimentary leaves on each side. The lower leaves approach and almost meet one another on the dorsal side (Plate V, fig. 35). The comparatively large number of rudimentary leaves in this specimen affords an additional reason for regarding it as a young form. The outer margin of the 10th leaf from below is 15 mm. in length and the leaf shows 7 rays projecting from its margin (Plate VIII, fig. 49).

The largest spicules of the rays are 4.75 mm. in length. In the autozooid zone there are several spicules of various sizes down to 0.75 mm. The spicules are mostly arranged parallel with the rays and some of the smaller ones project from the calices.

The siphonozooids on the leaves form a basal plate, which meets the narrow autozooid zone at the ventral edge. The mesozooids of the ventral track form a long single row widely separated from one another.

The long and rather slender stalk is cylindrical in shape with a diameter of 5 mm. and shows a very slight enlargement in the region of the sphincter muscle.

Perhaps the most remarkable feature of the specimen is that the stalk is provided with abundant large needle shaped spicules (1.4 × .07 mm.) arranged longitudinally (Textfig. 40 p. 225). These spicules can easily be seen with the naked eye through the transparent tissues.

The colour is pale yellow with many orange coloured blotches on the leaves and stalk. The dorsal track is almost uniformly orange coloured.

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All the tissues are remarkably transparent.

The general description of this single specimen may read as follows: — A very transparent colony of spongy texture and medium size. The rachis a little longer than the stalk and about two thirds as wide as it is long. The leaves on each side 22—24 in number, of which 5—7 are rudimentary, sickle-shaped, with a strongly developed dorsal ray and five or six others, all projecting as spines from the margin. The siphonozooids in the form of a narrow basal plate which meets the autozooid zone at the extreme ventral edge (Plate VIII, fig. 49). A long row of widely separated mesozooids on the ventral track. The largest spicules of the rays 4.7 mm. in length. Numerous large spicules (1.4 mm.) in the cortical layer of the stalk.

4. *Pteroeides caledonicum* Kölliker. (Pl. VIII, fig. 54 and Text figs 41 & 43).

Pteroeides caledonicum Kölliker 1872. Die Pennatuliden. p. 75, Pl. IV.
Struthiopteron elegans Broch 1910. Zool. Anz. XXXVI, p. 63.
Struthiopteron caledonicum Kükenthal & Broch 1911. "Valdivia" Pennatulacea. p. 437, Pl. XXIII.

Stat. 181. Amboyna. 3 Ex. + 1 loc. incert.

This species was referred to a distinct genus by Broch (1910) on the ground of the presence of the small outgrowths at the base of the dorsal margin of the leaves which I have called the "stipules". In all other characters the species is essentially a Pteroeides and I cannot understand what useful purpose can be served by burdening the literature with an additional generic name on such a slight and really unimportant character. As already pointed out by Kükenthal and Broch (1911 p. 436), a similar structure in connexion with isolated leaves occurs in another species (*P. griseum*) but I have found that quite distinct stipules of exactly the same kind occur on no less than 15 pairs of leaves in some specimens of *Pt. malayense* (see p. 247 Plate V, fig. 34) and similar structures also occur in *Pt. Esperi* (p. 222). My impression is that the stipule is simply an excrescence produced when there is a tendency to form very large leaves and that it is of no generic value.

The species however is a good one and can be distinguished from *Pt. malayense*, to which it is in some respects closely related; 1st by the presence of stipules on all the leaves and 2nd, by the presence of a few oval spicules (.047 × .013) in the cortex of the stalk. These oval spicules in the stalk are very different in appearance from those of any other species I have examined. A good figure of them is given by Kükenthal and Broch (1911 p. 438) but the size given by these authors is greater viz.: .08 mm. The specimens agree more closely with Kölliker's original description of the species, in the large number of rays, than with the description of *Struthiopteron caledonicum* given by Kükenthal & Broch. The number in the large Siboga specimens is 18—19, in the smaller specimens (95—110 mm.) described by Kölliker 9—17 and in the medium sized specimen (145 mm.) of Kükenthal and Broch only 8—9.

Kölliker's specimens were found off New Caledonia and the specimen examined by Kükenthal and Broch came from Amboyna.

The principal measurements of the four specimens are as follows: —

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	I	II	III	IV
Total length	173 mm.	212 mm.	167 mm.	172 mm.
Length of rachis	93 „	112 „	85 „	76 „
Length of stalk	80 „	100 „	82 „	96 „
Breadth of rachis. . . .	?	?	56 „	50 „
Diameter of stalk . . .	15 „	18 „	12 „	16 „
Breadth of dorsal track	9 „	7 „	4 „	10 „
Number of leaves . . .	23—24	29—30	24—25	31

In all four specimens the base of the stalk is imperfect or damaged and the measurements for its length given above must be regarded as only approximate. Specimens I and II were partially dissected by Mrs MUSGRAVE and I cannot give reliable measurements of the greatest breadth of their rachis

The rachis. The rachis of these specimens is massive, of great width and thickness. The leaves are very large and crumpled, meeting on the ventral side and having the appearance of being densely crowded. The leaves are not however very numerous for the size of the rachis and it is quite possible that when the animal is alive and the leaves fully expanded they do not give a crowded appearance.

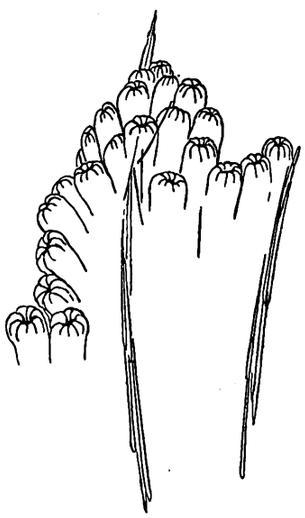

Fig. 43. *Pteroeides caledonicum.* A part of the margin of a leaf seen from the under side showing two rays and a few small spicules arranged on the calices of the autozooids.

The leaves are thin and transparent with 18—19 well marked rays formed of spicules reaching to a maximum length of 13.25 mm. Between the rays there are a few spicules, varying from 1—4 mm. in length, which seem to be confined to the calices of the autozooids (Textfig. 43). In some specimens larger spicules than these are found between the autozooids but there are very few spicules, except the ray spicules, found in any specimen below the autozooid zone. I have not found any example of a forked ray such as were described by KÜKENTHAL and BROCH in their specimen which also came from Amboyna.

The autozooid zone is very narrow (circa 3 mm.). The calices are very irregularly distributed on both sides of the margin but there are rarely more than three in a row on either side.

The siphonozooid plate is of considerable extent with long pointed processes extending for some distance up the rays. It meets the margin on the ventral side and extends on to the lower surface of the stipule on the dorsal side. At the base the siphonozooids are widely scattered and in some leaves absent or very scarce (Plate VIII, fig. 54).

The siphonozooid plate in our specimens accords much more closely with the description given by KÖLLIKÉR (1872 p. 76) than with that given by KÜKENTHAL and BROCH (1911 p. 437). It is a plate which is intermediate between the typical "median" plate and the typical "marginal" and "basal" plates. In some cases it would be called "marginal" in others "median" and in others "basal" and may be taken as good example of the difficulty of grouping the species of Pteroeides by the character of the siphonozooid plate.

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The length of the outer margin of the leaf in specimen 1. was no less than 45 mm., in the others it was 28, 30 and 35 mm. respectively. These measurements give a good idea of the enormous size of the leaves.

The stipules are present at the base of all the leaves, even on the youngest leaves. The largest stipules in the middle of the rachis are 10 mm. in width. They show three or four projecting spicules and are crowded with siphonozooids on the lower or proximal surface.

The dorsal track is long, oval in shape with a maximum width in the middle. The immature leaves below are inclined towards the dorsal side as in many specimens of *Pt. malayense*.

The ventral track shows a long row of mesozooids and for a short distance from the upper end they are three abreast.

The stalk. The large thick stalk shows well marked swellings in the region of the sphincter muscle. There is no trace of a terminal bulb (Endblase). The anatomy of the stalk of one of these specimens (4) has been well described and illustrated by Mrs MUSGRAVE (1909 p. 465, Pl. XXVII, fig. 14).

It is only necessary to add to her account the statement that in the skin of the stalk there are a few very small oval spicules (.047 × .013 mm.) (Textfig. 41 p. 225).

The axis in one specimen, in which it was fully exposed by dissection, was black in colour cylindrical in shape, with a maximum diameter 3.5 mm. It gradually becomes more slender at each extremity.

The colour varied considerably in the four specimens. In 1 and 4, the pale yellow rachis is marked with slate blue or grey blotches, the stalk being uniform pale yellow. In 2 the rachis is almost uniformly slate blue. In 3 the leaves only are tipped with blue patches.

It was between the leaves of one of the specimens of this species that some examples of the crab Porcellanella were found.

The affinities of this species appear to me to be with *Pteroeides malayense*. The clearly defined rays, the very large spicules in the leaves, the basal siphonozooid plate becoming marginal in the larger leaves, the presence of stipules, the great width of the rachis, the colour patterns and other characters all suggest that *Pteroeides caledonicum* is little more than a large well grown variety of *Pt. malayense*. The small oval spicules in the stalk and the very narrow autozooid zone are characters which justify perhaps its separation as a distinct species. But it is very difficult to understand the reasons for separating it into a different genus having a place between *Pteroeides* and *Sarcophyllum*, as KÜKENTHAL and BROCH have done.

A description of a young Pteroeides that may belong to this species is given on p. 249.

5. *Pteroeides Steenstrupii* Kölliker.

Pteroeides Steenstrupii Kölliker 1872. Die Pennatuliden. p. 362.

Rijksmuseum at Leiden. Malay Archipelago. 3 Ex.

KÖLLIKER described a specimen of Pteroeides in the Museum at Copenhagen from Surabaya on the Coast of Java to which he gave the name *Pt. Steenstrupii*. In the Museum at Leiden there are several specimens of a species that is not represented in the Siboga collection

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and one of them has kindly been sent to me for examination by Dr. HORST. One of these specimens was found by Mr. VAN DER SANDE in 1901 off the East coast of the Atjeh river in Sumatra and the others by Mr. J. P. BUITENDIJK in 1907 and 1908 off Tandjong Priok and the bay of Batavia, Java.

I do not propose to describe the specimen sent to me in detail as it resembles very closely the description of the type given by KÖLLIKER.

The following figures will show that the measurements of the specimen from Tandjong Priok correspond very closely with the measurements of the specimen described by KÖLLIKER from Surabaya.

	Tandjong Priok example.	Surabaya example.
Total length.	172 mm.	142 mm.
Length of rachis	105 „	93 „
Length of stalk	72 „	49 „
Breadth of rachis	65 „	66 „
Greatest diameter of stalk .	15 „	15 „
Number of leaves.	30	30
Number of rays.	20	22—23

The description of the colour of his specimen corresponds very closely with the colour of all the specimens in the Leiden Museum and as it is not only constant but different from that of any other specimens I have ever seen, the colour in this case is an important character. KÖLLIKER's description is as follows: — "Farbe gelblich mit Ausnahme eines braunen Streifens in der Mitte der Ventralseite des Kieles, der Polypen der oberen Blätter, der ventralen Zooidstreifen, des Zooidstreifens am Kiele und einzelner der oberen Zooide, die braunschwarz erscheinen".

In the Tandjong Priok specimen the very well marked stripe of blue-black pigment, running down the middle of the dorsal (i. e. KÖLLIKER's ventral) track, is from 3 to 4 mm. in breadth.

Round the base of the anthocodiae of all the autozooids, not only those of the upper leaves, there is a ring of the same pigment which in some of the leaves spreads out in flecks or spots over the autozooid zone. The siphonozooids of the ventral track have approximately the same distribution as in the type and are also marked out by the pigment. The other parts of the rachis and the stalk are pale yellow.

The Atjeh specimen differs from the Tandjong Priok specimens in having wider leaves and more rays, in that respect approaching more closely the description of the type.

6. *Pteroeides malayense* n. sp. (Pl. V, figs 33 & 34; Pl. VIII, figs 53 & 57; Textfigs 41 & 44).

? *Pennatula grysea* Esper 1791. Pflanzenthiere. Vol. III, p. 81.
? *Pteroeides Esperi* Herklots 1858. Polypiers nageurs. p. 20, Pl. II.
? *Pteroeides Esperi* (ex parte) Kölliker 1872. Die Pennatuliden. p. 108.

Stat. 79. 2° 43′ S., 117° 44′ E. Borneo bank. 41—54 metres. 9 Ex.
Stat. 79ª. 2° 38′ S., 117° 46′ E. Borneo bank. 54 metres. 5 Ex.
Stat. 133. Off Lirung, Salibabu. 36 metres. 1 Ex. (Imperfect).
Stat. 240. Banda Anchorage. 9—36 metres. 1 Ex.
Loc. incert. 1 Ex.

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The localities given by PALLAS (1766 p. 367) for the *Penna grysea* of BOHADSCH are "Mediterranean Sea and the Indian Seas". HERKLOTS in 1858 separated the "Indian Seas" form from the Mediterranean Sea form under the name *Pteroeides Esperi*, and under this name specimens have been described from various localities in the Indian Ocean, Japanese Seas and the Philippine Islands by KÖLLIKER (1872 pp. 109 & 363), by MARSHALL and FOWLER (1887 (2) p. 275), by BALSS (1910) and by KÜKENTHAL and BROCH (1911 p. 433).

Since the time of KÖLLIKER, authors have agreed in placing *Pteroeides Esperi* in the group of species that have a "marginal siphonozooid plate" and tacitly assumed that the specimen from Sumatra described by HERKLOTS exhibited the same character.

HERKLOTS wrote at a time when the nature of the siphonozooids was not known and their position was not accurately recorded but, in writing about the leaves, he says "Leur base est couverte d'une membrane granuleuse, coriace, qui porte des granules très développés serrés vers la marge posterieure de la pinnule" and it seems quite as likely as not that this is a description of a "basal" siphonozooid plate and not of a "marginal" one.

The specimens collected by the "Siboga expedition" which I have put in the new species *Pteroeides malayense* correspond fairly well with the figures and description of *Pt. Esperi* given by HERKLOTS but they differ, in the position of the siphonozooid plate and in some other characters, from the description of this species given by subsequent authors.

As it is impossible to determine with certainty whether our specimens are or are not identical with the specimen described by HERKLOTS and as it is the custom to describe under the name *Pteroeides Esperi* a species with "marginal" siphonozooid plates and other characters that do not agree with our specimens a new specific name becomes a necessity.

The principal measurements of the specimens are given in the following tables: —

Measurements of specimens of *Pteroeides malayense* from Stat. 79.

	1	2	3	4	5	6	7	8	9
Total length	143	146	162	128	163	139	160	155	135
Length of rachis	84	84	117	81	121	86	98	102	77
Length of stalk	59	62	45	47	42	53	62	53	58
Breadth of rachis	82	75	81	65	86	82	85	76	65
Breadth of dorsal track	10	9	15	12	10	11	12	8	10
Length of dorsal margin of leaf	35	40	33	29	38	39	40	34	31
Greatest diam. of sphincter region of stalk (dors. ventr.)	15	14	9	11.5	11	14	14	10	11
Mid. diam. of stalk	10	11.5	10	9	10	12	10	9	8.5
	L. R.	L. R.	L. R.	L. R.	L. R.	L. R.	L. R.	L. R.	L. R.
Number of leaves	33 34	29 31	32 33	32 31	34 33	32 29	34 36	32 32	30 30
Number of rays	15—18	18	16—18	18	15—17	18	18 + 2 small on 1 leaf	18—19	16—18

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Measurements of *Pteroeides malayense* from Stat. 79ª (1—5) from Loc. Incert. (6) from Banda (7).

	1	2	3	4	5	6	7
Total length	201	142	182	113	142	184	104
Length of rachis	148	80	112	75	98	104	75
Length of stalk	53	62	70	38	44	80	29
Breadth of rachis	89	84	85	76	58	88	37
Breadth of dorsal track. . . .	20	11	20	15	12	14	9
Length of dorsal margin of leaf	38	39	35	34	22	38	18
Greatest diam. of sphincter region of stalk (dors. ventr. or right left).	20.5 R. L.	17 D. V.	14 D. V.	15	13 R. L.	20	11
Mid-diam. of stalk	11	10	9.5	18	7	13	8
	L. R.	L. R.	L. R.	L. R.	L. R.	L. R.	L. R.
Number of leaves	38 36	35 36	37 37	33 32	32 32	40 39	18 18
Number of rays	16—18	18	18—19	18—19?	17—18	18—19	?

The figures given in these tables show some points of special interest. The ratio of length of rachis to length of stalk varies from 13 : 13 to 28 : 1 in the specimens from Station 79 and from 11 : 10 to 28 : 10 in those from Station 79ª.

According to KÜKENTHAL and BROCH this ratio varies from 8 : 10 to 16 : 10 in *Pt. Lacazii* and from 12 : 10 to 28 : 10 in *Pt. Esperi*.

This ratio however cannot be of any value for systematic purposes. In a genus like Pteroeides in which the stalk is provided with such an elaborate and powerful muscular system (cf. MUSGRAVE 1909) the actual length of the stalk must vary enormously in the preserved specimens according to the condition of the specimens at the time they were preserved and the nature of the preservative used.

One of the most striking features of the group of specimens is the great breadth of the rachis as compared with its length, a feature which is correlated with the great length of the dorsal margin of the leaves. In this respect they resemble *Pt. Esperi*, *Pt. tenerum*, *Pt. chinense* and *Pt. grisea* more closely than they resemble *Pt. Lacazii*.

The most constant figures in the table are the number of leaves and the number of rays on the leaves. They vary to some extent with the total length but nevertheless the number of the rays appears to me to be the most useful character for the determination of species.

The rachis. The rachis is very broad, the greatest width being usually in the region of the 15th leaf counting from below upwards. The leaves are very large and fan-shaped, meeting on the ventral side with a moderately broad autozooid zone (circa 6 mm.) and a narrow basal plate of siphonozooids. There are 15—19 principal rays formed by very long overlapping spicules with a maximum of 11 mm. in length and spicules between the rays of

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various sizes from 3—0.5 mm. in length are scattered more or less irregularly in the autozooid zone (Text fig. 44). The leaves are thin and moderately transparent.

The rows of immature leaves at the base of the rachis are usually inclined towards the dorsal side and in some specimens almost meet. (Compare Plate V, figs 33 & 34).

In some specimens there are rudimentary stipules at the base of the dorsal margin of the leaves. In one specimen (Pl. V, fig. 34) there are no less then fifteen pairs of these stipules in others not so many, and again in others there is no trace of them. In the largest of these stipules three spines can be seen projecting, like rudimentary rays. They are covered with siphonozooids but I have never yet seen any trace of autozooids in them (cf. p. 217).

The dorsal track is usually broadest in the middle. The ventral track is usually hidden above by the meeting of the leaves. The mesozooids it bears are, in some specimens, very difficult to observe without dissection, but they appear to be very variable in number and position. In 3 specimens three rows of these mesozooids were seen above, in others only one row but I found it very difficult to determine how far they extend down the track with any degree of precision. These mesozooids cannot be seen further down than one third the distance from the distal end in any specimen and the row or rows appear to be short in all cases.

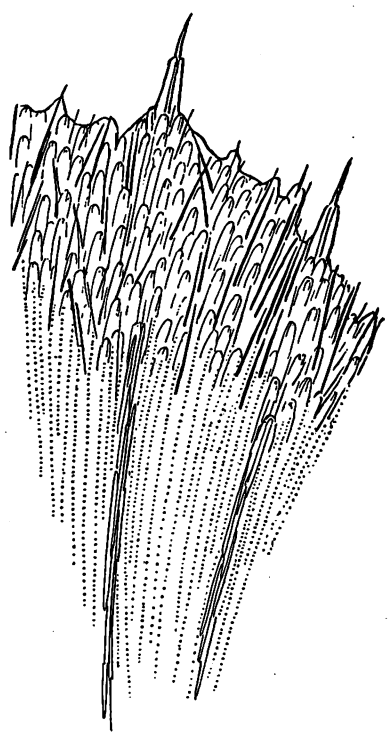

Fig. 44. *Pteroeides malayense.* A part of the margin of a leaf showing two rays and the spicules of various sizes arranged in the autozooid zones.

The siphonozooids are arranged in a basal plate (Pl. VIII, fig. 53) in all the specimens except one in which the plate is marginal. There is considerable variation in the width of the plate and in a few cases it has a dentate edge.

The stalk. The stalk shows a swelling in the region of the sphincter muscle but this is not usually very pronounced. Below the swelling it is cylindrical in shape and then comes to an abrupt termination. The base is ruptured in many specimens and the axis exposed.

The spicules in the cortical layers of the stalk are rods or needles, fairly abundant in the specimens from Stat. 79[a] (Text fig. 41 2. p. 225) 0.172 × 0.013 mm., but much less abundant and smaller (.08—.12 mm. in length) in the specimens from Stat. 79.

The colour is very variable. The specimens from Stat. 79 are straw coloured with more or less numerous blotches of slate blue colour on the leaves, dorsal track and upper parts of the stalk. These out of the five specimens from Stat. 79[a] are very much darker, the rachis being almost entirely a dark slate blue colour.

The specimen 4 from Stat. 79[a] is very remarkable as it shows in some respects a close approach to *Pteroeides Esperi.* Although it is smaller than most of the specimens, the leaves are thicker, the autozooid zone much broader and the siphonozooid plate has long dentate processes extending up the rays and almost meets the autozooid zone at the ventral edge. It

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has more leaves however for its length than *Pt. Esperi* and the spicules in the cortical layer of the stalk are very small. This specimen was the darkest in colour of them all.

One specimen of the little Galatheid crab *Porcellanella picta* (Simpson) was found between the leaves in one of the specimens from Station 79.

The new species may be described briefly as follows: — "Colonies stout and fleshy, "with a very broad rachis, with very large but rather thin leaves, not very closely set, 30—40 "in number on each side. Each leaf with 16—19 rays, a moderately broad "autozooid zone "and a basal siphonozooid plate. The lower leaves in many specimens tending towards the "dorsal side of the rachis. Mesozooids on the ventral track in one to three rows extending "a short way from the upper end. The spicules of the principal rays are very large with a "maximum length of 11 mm. Spicules of the cortical layer of the stalk variable in number "and size but not exceeding 0.2 mm. The colour in spirit is yellow with variable patches or "blotches of slate-blue. Malay Archipelago. 0—54 metres".

The affinities of the new species are with (1) *Pteroeides Esperi* of HERKLOTS with which it agrees in its form and texture, the size, shape and arrangement of the leaves and approximately with the number and construction of the rays. It also agrees with *P. Esperi* in the arrangement of the mesozooids on the ventral track of the rachis.

It differs from *Pt. Esperi* in several respects: —

The siphonozooid plate on the under side of the leaf *Pt. Esperi* is described by KÖLLIKER (1872 p. 108) as marginal and "zackig begrenzt", in *Pt. malayense* it is basal and does not usually show a dentate margin.

As this is an important point in the determination of the species of Pteroeides over a hundred leaves were carefully examined and the arrangement of the siphonozooid plate was found to be practically the same in all. In some cases a few dentations were observed extending along the rays but in only one case did the siphonozooid plate reach the autozooid zone.

Associated with this point of difference is another. In *Pteroeides Esperi* the autozooid zone is described as "broad" (KÖLLIKER) or "very broad" (KÜKENTHAL and BROCH).

In *Pt. malayense* it must be called rather narrow or moderately broad as it does not usually extend for more than one sixth of the distance from the margin to the base. The leaves of *Pt. Esperi* are described by KÜKENTHAL and BROCH as moderately thick so that the rays can be imperfectly seen. In *Pt. malayense* they are thin and transparent so that the rays can quite easily be seen. The number of leaves in a specimen (112 mm. in length) of *Pt. Esperi* is 25. In a specimen of *Pt. malayense* of similar size it is 33.

It is difficult to compare the length of the large spicules of the rays in the two species as the measurements are not given by most of the authorities. In the small specimen (49 mm.) of *Pt. Esperi* examined by KÜKENTHAL and BROCH these spicules are said to reach a size of 7 mm. They seem to be rather exceptionally large in *Pt. malayense* as they are frequently 11 mm. in length, a size which is only exceeded by those of *Pt. latissimum* according to the statements of KÜKENTHAL and BROCH.

With these points of difference it is clear that *Pt. Esperi* and *Pt. malayense* cannot be

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regarded as synonymous, but some doubt may be expressed whether some of the specimens collected by BLEEKER in Java and imperfectly described by KÖLLIKER, such as his varieties "*latifolium*" and "*angustifolium*" are not identical with our new species..

Pteroeides Lacazii Kölliker agrees with *Pt. malayense* in the position of the siphonozooid plate, in the number of the leaves (30—40), in the number of rays, and in the thinness and transparency of the leaves, but after comparison with specimens of *Pteroeides Lacazii* determined by KÖLLIKER himself (viz. *Pt. Jukesii* Gray and *Pt. oblongum* Gray) in the British Museum, I am convinced that *Pt. malayense* is quite distinct, although the occurrence of *Pt. Lacazii* in the Malay Archipelago has been described by ROULE (1908 p. 189) and by KÖLLIKER (1872 p. 62).

Pt. Lacazii is a much more slender species with smaller leaves and a longer stalk, much smaller spicules in the rays and larger spicules in the stalk.

The new species has affinities also with *Pteroeides griseum* ot the Mediterranean sea but this species again has fewer leaves and much smaller spicules.

Of the species described by THOMSON and SIMPSON (1909 p. 292) it is difficult to form an opinion as we are not assisted by figures but, judging from the measurements, the new species may be related to *Pt. robustum*. It differs however from this species in the number of leaves, the width of the autozooid zone and the absence of spicules in the stalk.

Appendix to genus *Pteroeides*.

Four very young specimens belonging to the genus Pteroeides may here be described.

As our knowledge of the young stages of the genus is so imperfect and there are no intermediate stages in the collection to compare them with, an accurate determination of the species is impossible.

The four specimens therefore will be called A., B., C. and D.

A. Young *Pteroeides caledonicum*? (Plate X, figs 71 & 72).

Stat. 37. Paternoster Islands. 27 metres and less. 1 Ex.

This little brown specimen is imperfect at the top the axis being exposed. From the general appearance of the rachis however it does not seem probable that very much has been lost.

The dimensions are: — Total length 24 mm.; length of rachis 11 mm.; length of stalk 13 mm.; width of rachis 7 mm.; diameter of stalk 2 mm.

The are 11 leavès on each side, and the larger leaves have four rays. At the margin of each leaf there is a single row of autozooid calices and on the under side a narrow median band of siphonozooids.

The most noteworthy feature however is the presence of a very definite stipule at the base of each leaf, and these stipules show from 1—3 projecting spicules (Plate X, fig. 71).

The cortical layer of the stalk is crowded with spicules, some oval in shape and some more rod-shaped. The oval forms reach a size of .06 × .02 mm. and the rods .06 × .01 mm.

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There are some of each kind rather smaller in size but no very small spicules or granules. The well developed stipules and the size and shape of the spicules of the stalk suggest that this a young form of *Pt. caledonicum*.

B. Young *Pteroeides speciosum*? Kölliker. (Plate X, figs 69 & 70).

Stat. 117. 1°0′ N., 122°56′ E. Kwandang Bay, Celebes. 80 metres. 1 Ex.

This specimen is also imperfect at the upper end.

The dimensions are: — Total length 63 mm.; length of rachis 30 mm.; length of stalk 33 mm.; width of rachis 5 mm.; diameter of stalk 3 mm.

The leaves have the form of the blade of a pen-knife or scalpel. There is a very strong ray on the dorsal margin composed of eight or nine large spicules 1 mm. or more in length and up to 0.14 mm. in diameter. This ray is 6 mm. in length.

Radiating fan-wise from the base of this are numerous needle-shaped spicules of various sizes which form more or less definite radiating lines passing to the margin of the leaf and projecting from the surface at the autozooid calices. There are about 30 autozooids arranged in a single row on the lower edge but overlapping into two indistinct rows above.

The siphonozooids are arranged in a group quite close to the base of the leaf. The position is technically "median" as there is a narrow band below the plate which is free from siphonozooids.

Notwithstanding the length of the leaf (6 mm.) its insertion on to the rachis is very narrow (1 mm.).

The skin of the stalk is crowded with long parallel needles 1.35 mm. in length and some of these can be seen with the naked eye to extend on to the dorsal track. These spicules are more numerous than the spicules of the stalk in the specimen referred to this species described above (p. 236).

The species *Pteroeides speciosum* was founded by KÖLLIKER (1872 p. 55) on a specimen in the Amsterdam Museum that is 261 mm. in length, and a specimen, probably a distinct species (see p. 237) in the Leiden Museum from Amboyna. Unfortunately the origin of the type specimen is unknown and no other specimens of the species have been discovered.

The reasons for suggesting that the specimen from Kwandang bay is a young form of *Pt. speciosum*; are 1st the shape of the leaves which are described as follows: — "Fiedern von der Gestalt der umgekehrten Vorderflügel eines Schwärmers (Sphinx) mit stark ausgezogener Spitze". 2nd the arrangement of the rays as shown in the figure (KÖLLIKER's plate III fig. 13). 3rd the arrangement of the siphonozooids described as follows: "Untere Fläche (of the leaves) mit einer kleinen gelben basalen Zooidplatte, die die relativ breite grau-gelbe Polypenzone nicht erreicht".

The siphonozooid plate in our specimen is technically "median" but if a few more siphonozooids were added on the under side as the growth proceeded, it would become technically "basal".

The principal difficulty, however, in accepting this identification is that KÖLLIKER does not mention the spicules of the stalk which are so large even in this small specimen that they can be seen with a simple lens.

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C. Young *Pteroeides sagamiense*? Moroff. (Plate X, fig. 73).

Stat. 240. Banda Anchorage. 9—36 metres. 1 Ex.

Another specimen obviously belonging to a similar but different species but smaller and more damaged was found in this locality.

The dimensions are: — Total length 18 mm.; length of rachis 10 mm.; length of stalk 8 mm.; greatest width of rachis 7 mm.; diameter of stalk 2 mm.

There are 9 leaves on each side four or five of them being very rudimentary. Many of the leaves seem to be partly macerated, but the spicules exhibit a similar arrangement to that of specimen B, namely a very strong dorsal ray from the base of which the other rays radiate. The spicules in the stalk however are not crowded and are very much smaller than in specimen B, not exceeding 0.1 mm. in length.

In this respect the Banda specimen resembles *Pteroeides sagamiense* Moroff (1902 p. 366) more fully described by Balss (1910 p. 64) and by Kükenthal and Broch (1911 p. 417).

Pteroeides speciosum and *Pteroeides sagamiense* are clearly related to one another in the structure of the leaf but the former is a much longer and more slender sea-pen. It is probable that the young forms of these two species would be difficult to distinguish by any other character than the spicules of the stalk.

D. Young *Pteroeides chinense* ?. (Plate X, figs 74 & 75).

Stat. 164. 1°42′ S., 130°47′ E. Near Seget Island. 32 metres. 1 Ex.

This small but very broad and fleshy specimen has the appearance of *Pteroeides chinense* on a small scale but as this species is not known to occur in the district and the arrangement of the siphonozooids on the leaves and other characters are different, it seems to me quite possible that it is a young form of some other species.

The measurements are: — Total length 20.5 mm.; length of rachis 13 mm.; length of stalk 7.5 mm.; width of rachis 20 mm.; diameter of stalk 4 mm.

A remarkable feature of this specimen — if it is a young one — is that there are no small rudimentary leaves at the lower end of the rachis.

On the right hand side the last leaf has a dorsal margin 5 mm. in length and on the left side 9 mm. in length, the latter being almost as great as that of the largest leaf of the rachis.

The dorsal margin of the largest leaf is 11 mm. in length. It has 12 or 13 rays which project from the margin as short spines formed of two or three spicules. The autozooid zone is narrow, the autozooids projecting on both sides of the leaf. The siphonozooid plate is distinctly median in position.

The spicules of the leaves are very large. One spicule from the dorsal ray is no less than 7 mm. in length × 0.2 mm. in diameter. There are 8 leaves on the left side and 9 on the right side of the rachis. The two leaves at the upper or distal end on the left side are very small or rudimentary.

There are no needle-shaped spicules in the cortical layer of the stalk but I have found a few very small granules, widely separated from one another, in this region.

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Specimens of the species *Pteroeides chinense* have been described from Amoy and from Banka by KÖLLIKER (1872 pp. 87, 88 & 360) from the Mergui Archipelago by MARSHALL and FOWLER (1887 p. 272) and by BALSS (1910) from Japan.

KÜKENTHAL and BROCH (1911 p. 432) regard this species is identical with *Pteroeides bankanense* of BLEEKER. To this identification there are many objections. The specimen of *Pt. bankanense* described by KÖLLIKER had only 12 rays in the leaves. In *Pt. chinense* the leaves have as many as 20 rays, as I have had occasion to confirm by an examination of one of MARSHALL and FOWLER's specimens in the Manchester Museum. It is true that BALSS gives a very wide rang of variation (8—18) in the number of rays in the two specimens from Japan attributed by him to the species *Pt. chinense* but the one with 8 rays was only 70 mm. in length and perhaps not fully developed.

The only other description of a young specimen of a *Pteroeides* is that given by KÖLLIKER (1872 p. 356 figs 314 & 315). This specimen was 25 mm. long and was regarded by him as a young specimen of *Pt. Lacazii*. It clearly belongs to a different species to any of those in our collection.

Genus **Gyrophyllum** Studer.

Gyrophyllum Studer, Th. 1901. Alcyonaires de l'Hirondelle. p. 34, Pl. IV.
Gyrophyllum Roule, L. 1905. Mus. Hist. nat. Paris. p. 454.

The genus was established by STUDER for a specimen (*G. hirondellei*) obtained in 1888 from a depth of 1266 metres off the Azores in the Atlantic Ocean. Since then ROULE (1905) has given the same name to 11 specimens from the same locality found at a depth of 1222—2220 metres.

By the kindness of Professor CH. GRAVIER of Paris I have been able to examine a specimen of *G. hirondellei* collected by the Talisman expedition. It is 110 mm. in length, with a stalk 70 mm. in length and five leaves on each side of the rachis. I have examined the spicules and find them to be of the same kind as the spicules of the Siboga specimen. There can be no doubt that the Siboga specimen belongs to the genus *Gyrophyllum*.

The specimens of Gyrophyllum from the Malay Archipelago and from the Atlantic Ocean are similar in general appearance and colour, in having siphonozooids on both sides of the leaves as well as on the dorsal track and in the size and arrangement of the spicules.

The following may serve as an amended definition of the genus: — Colony stout and fleshy, with a long stalk and a few large thick leaves. Autozooids provided with short thick-lipped calices. Siphonozooids distributed on both sides of the leaves and on the dorsal track. Spicules rod-shaped, rounded at the ends and 3-flanged or more irregularly ridged 0.3—0.5 mm. in length, densely crowded in the leaves, rachis and stalk. Spicules of the tentacles and body wall of the anthocodiae broad ridged rods about 0.2 mm. in length. Deep water in Atlantic Ocean and Malay Archipelago.

STUDER placed the genus in the family Pteroeididae, but KÜKENTHAL and BROCH (1911 p. 394) in discussing the position of the genus considered that if the spicules are 3-flanged

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(dreiflügelig) it should not be placed in this family. The spicules of the leaves both in our specimen and in the specimen from the Atlantic Ocean do exhibit the characteristic flanges of the spicules of Pennatula and in that respect therefore they differ from other Pteroeididae.

The presence of siphonozooids on both sides of the leaves, as well as other characters of a more general kind, suggest that the genus ought not to be placed in the family Pennatulidae.

The genus appears to me to show stronger affinities with the family Pteroeididae than with the Pennatulidae. The general appearance of the specimens at once suggests that they are Pteroeididids and it becomes a question whether the occurrence of 3-flanged spicules should be regarded as a more important clue to affinity than the occurrence of siphonozooids on the leaves. It is my opinion that the presence of ridges on the spicules should not be regarded as a character of such great importance as to necessitate the dissociation of the genus from the family Pteroeididae with which in other respects it has strong affinities and I should also strongly disapprove of any proposal to raise the genus to family rank.

There are only two species: —

1. With calyx teeth. *G. sibogae* n. sp. Malay Archipelago.
2. Without calyx teeth. *G. hirondellei* Studer. Atlantic Ocean.

1. *Gyrophyllum sibogae* n. sp. (Plate III, fig. 17; Plate VIII, fig. 48; Text fig. 45).

Stat. 173. 3° 17′ S., 131° 0′ E. Near Ceram. 567 metres. 1 Ex.

The single specimen of this fine new species is larger than the type specimen of the only other species of the genus. In both specimens the stalk is a great deal longer than the rachis and the number of pairs of leaves is very small for such a large pennatulid.

For the sake of comparison the measurements of the two species are given side by side.

	G. sibogae.	*G. hirondellei.* (Type specimen).
Total length	295 mm.	127 mm.
Length of rachis.	100 „	47 „
Length of stalk	195 „	80 „
Breadth of rachis	60 „	40 „
Diameter of stalk	7 „	6 „
Number of leaves on each side	8	7

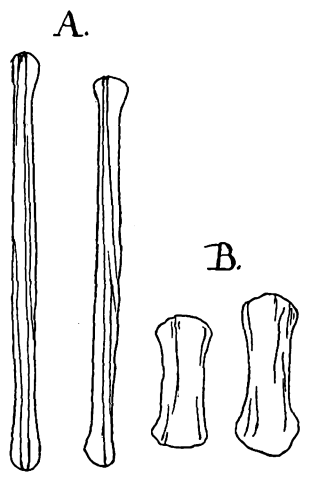

Fig. 45.
Spicules of *Gyrophyllum Sibogae*.
A. of the leaves. B. of the tentacles.
× 100 diam.

The rachis is provided with eight pairs of thick fleshy leaves with undulating margins. Of these the leaves of the proximal pair are unequal in size the one on the left of the axis being 26 mm. in width and that on the right 38 mm. in width. The leaves of the second pair from below are nearly equal in size but considerably larger than the first pair. Those of the third, fourth fifth and sixth pairs are about the same size and slightly larger than the second pair. The leaves have unfortunately been somewhat distorted in the process of preservation and in packing, so that it is impossible to give the exact measurements, but the following may be some guide for the future. The width of the largest leaves is about 60 mm. and the

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height (from the base to the extremity of the calices) about 30 mm.; the thickness of each leaf is about 3.5 mm.

The two distal pairs of leaves are much smaller than the others, the pair at the actual extremity consisting of leaves not more than 15 mm. in width.

The leaves are inserted at a considerable angle to the transverse plane of the rachis, passing from above on the ventral side to a much lower position on the dorsal side.

In the numeration of the leaves I have followed STUDER, believing that the first formed pair of leaves is that nearest to the stalk and that new leaves are added at the distal extremity.

The pairs of leaves are separated from one another by considerable intervals (10—12 mm.) but from the position in which the specimen was killed or owing to some pressure during preservation the leaves appear to be very much crowded together at the extremity (see Pl. III, fig. 17). This appearance is probably not natural.

The autozooids of the specimen were completely retracted. The openings of the calices are arranged irregularly in one, two or three rows at the free border of each leaf. Each calyx is very short but in some cases continued as a long ridge on the surface of the leaf. It is provided with a pair of lateral, short, stout papilliform teeth (Pl. VIII, fig. 48). These teeth are crowded with white spicules. The absence of these teeth from a good many of the calices may be due to post mortem injury but it is also possible that there is a considerable amount of variation in this respect.

The anthocodiae can be easily dissected out from the calices and, from their texture, I conjecture that they are of considerable size when fully expanded. The tentacles are provided with very numerous and very long pinnules of a brown colour. The pinnules have no spicules, but the axes of the tentacles and the body wall of the anthocodiae at the base of the tentacles are provided with a considerable number of short stout spicules of a peculiar kind described below (Text fig. 45 B.). These spicules extend on to the body wall below the crown but their exact distribution was undetermined.

The siphonozooids are very numerous and are distributed on both faces of the leaves. They form very well marked verrucae about 5 mm. in diameter (Pl. VIII, fig. 48).

There are also numerous siphonozooids on the dorsal track. These siphonozooids however are not so prominent as those on the leaves and I cannot determine whether they are evenly distributed all over the track or whether there are spaces free from them. It was not until a thin slice cut off the middle of the rachis was stained and cleared in oil that it could be determined with certainty that siphonozooids do occur. The specimen being unique, the investigation of this point was not carried further.

The stalk is long, cylindrical and smooth. At a little distance from the rachis there is a considerable swelling the diameter increasing from 7 to 12 mm. and at the base there is a well marked bulbous swelling 10 mm. in diameter.

The spicules in the leaves are long rods or spindles with rounded ends provided with three longitudinal flanges (Text fig. 45 A). These flanges are usually a little oblique but in some cases run almost parallel with the long axis of the spicule. The spicules are present in considerable numbers in the cortical layers but extend all through the substance of the leaf.

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They are densely crowded together in the teeth of the calices. They vary to some small extent in size but the majority of them are about 0.5 mm. in length by .03 mm. in breadth.

The spicules of the anthocodiae are shorter and broader than the other spicules of the leaves having an average length of about 0.2 mm. and average breadth of .07 mm. Their shape might be described as rod-like but there is great variety in the marking at the extremities and on the surface. Many of these spicules have a rough resemblance to the phalangeal bones or caudal vertebrae of a vertebrate animal. The ridges and terminal knobs are doubtless adapted to the needs of expansion and retraction of the ancothodiae.

In the dorsal track of the rachis there is a honey-comb of rod-shaped spicules of variable size but of an average length of about 0.35 mm.

The cortical layer of the stalk appears to be provided throughout with densely crowded spicules. In the upper swelling the spicules are spindle shaped with an average length of about 0.3 mm.

In the basal bulb the spicules are rod-shaped but provided with flanges like the others. They are of a fairly uniform size .2 mm. in length by .05 mm. in breadth.

In the specimen of *G. hirondellei* sent to me by Professor GRAVIER the spicules of the rachis are 0.3 × 0.4 mm. and of the tentacles 0.2 × .05 mm.

They are therefore of approximately the same size as those of *G. sibogae* and have the same form and distribution.

The axis. No part of the axis is visible in the specimen but judging from the rigidity of the rachis and of the stalk there can be little doubt that the axis extends throughout the whole length of the pen. According to ROULE the axis of *G. hirondellei* is quadrangular.

The colour of the specimen is pale brown. In some places where the tentacles protrude from the mouths of the calices there are dark brown patches.

With only one specimen of the malayan species as a guide it is impossible to determine the specific characters with certainty. The following may serve, however, as a provisional statement of the characters of the species: —

G. sibogae. Gyrophyllum of large size with eight pairs of large leaves. Anthocodiae completely retractile into short calices provided with two teeth. Siphonozooids numerous on both sides of the leaves and on the dorsal track. Spicules in the leaves about 0.5 mm. in length. Spicules of the tentacles 2 × .07 mm. Malay Archipelago. 567 metres.

G. hirondellei Studer is smaller in size and does not show the two prominent teeth on the calices.

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EXPLANATION OF THE PLATES.

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PLATE I.

Fig. 1. *Veretillum malayense*. Nat. size.
Fig. 2. *Chunella biflora* n. sp. Stat. 302. Nat. size.
Fig. 3. *Sclerobelemnon Burgeri* (Köll.). One of the specimens seen from the ventral side showing some verrucae (pseudocalices). × 1½ diam.
Fig. 4. *Chunella biflora* n. sp. Young specimen from Stat. 167. × 2 diam.
Fig. 5. *Sclerobelemnon Gravieri*. New species. Seen from the ventral side. × 3 diam.
Fig. 6. *Distichoptilum gracile*. Station 45. × 15 diam.
Fig. 7. *Distichoptilum gracile*. Station 271. A portion of the rachis seen from the dorsal surface showing a deep groove (*gr.*) and the position of the siphonozooids (*Si.*). × 15 diam.
Fig. 8. *Chunella gracillima*. One of the whorls of three autozooids. Ventral view. × 4 diam.
Fig. 9. *Chunella gracillima*. One of the whorls of three autozooids. Dorsal view. × 4 diam.

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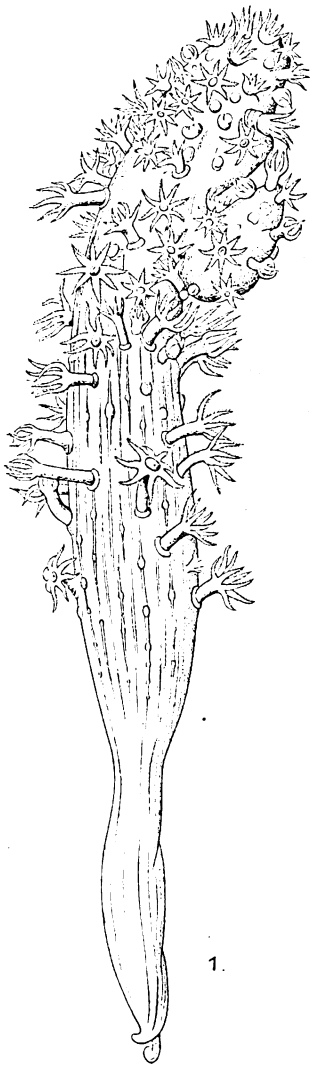

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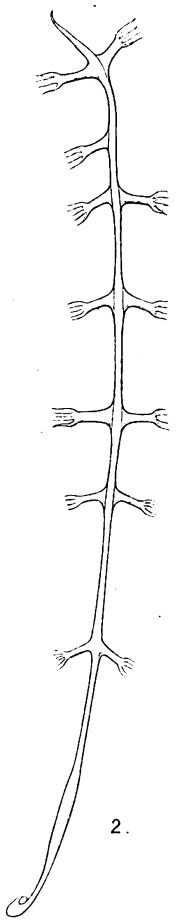

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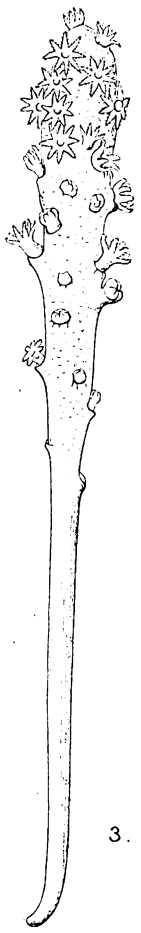

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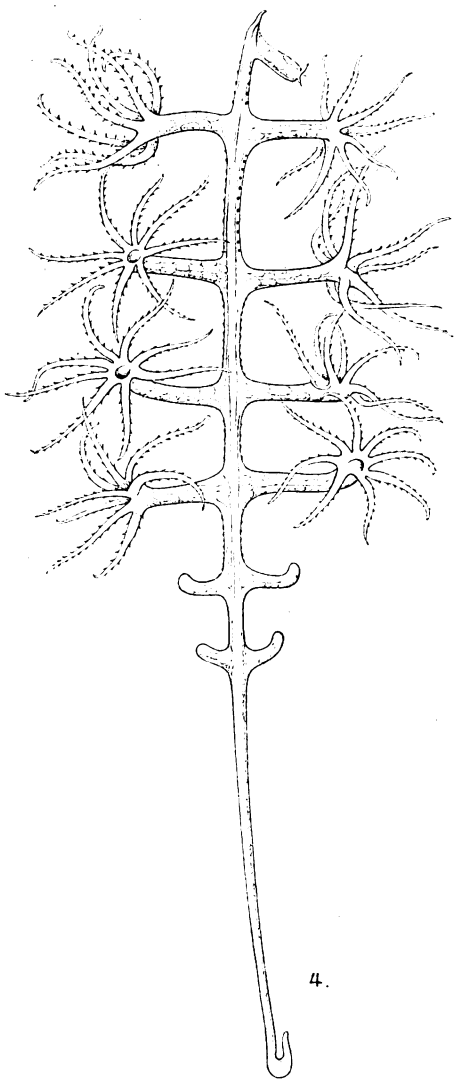

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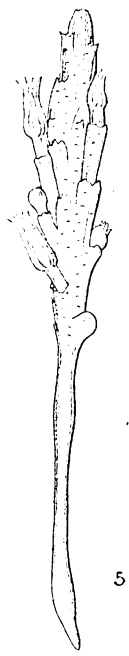

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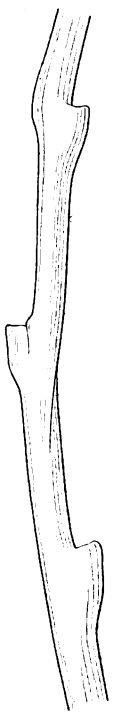

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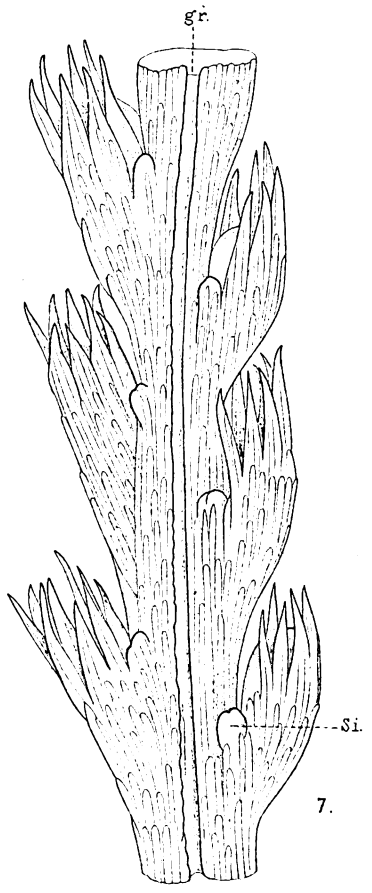

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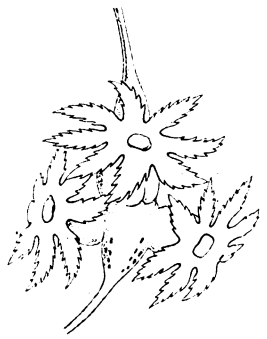

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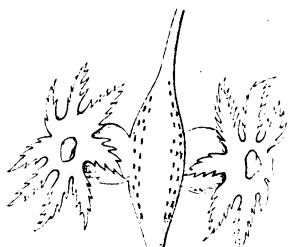

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PLATE II.

Fig. 10. *Sclerobelemnon magniflorum.* New species. Seen from the dorsal side. × 2 diam.
Fig. 11. *Sclerobelemnon magniflorum.* New species. Seen from the ventral side. × 2 diam.
Fig. 12. *Sclerobelemnon elongatum.* New species. A part of the rachis of one of the large specimens. × 2 diam.
Fig. 13. *Kophobelemnon pauciflorum.* A young specimen from Station 137. × 8 diam.
Fig. 14. *Sclerobelemnon Burgeri.* A young specimen from Stat. 258. × 4 diam.

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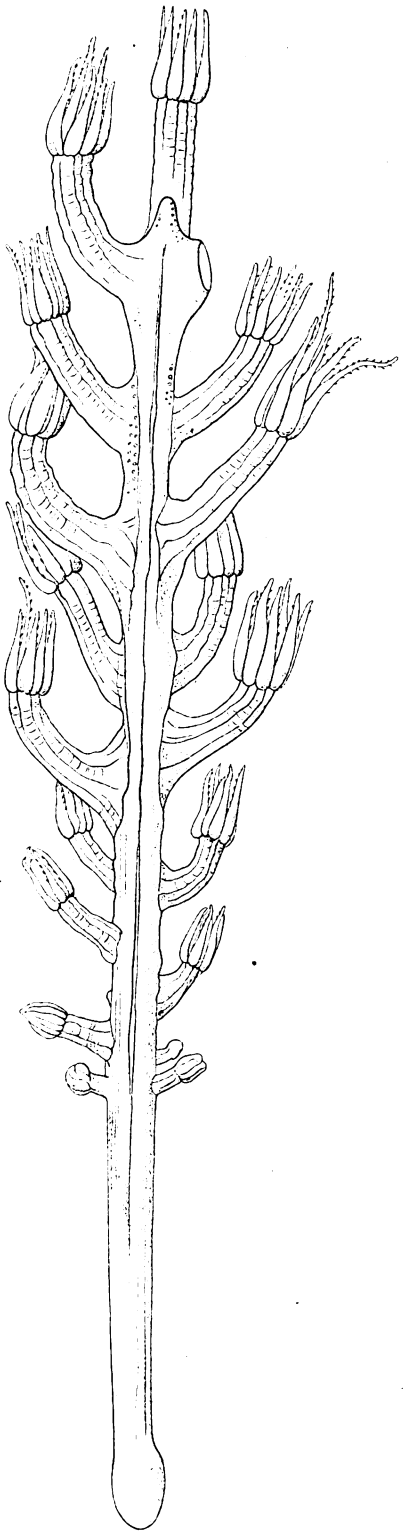

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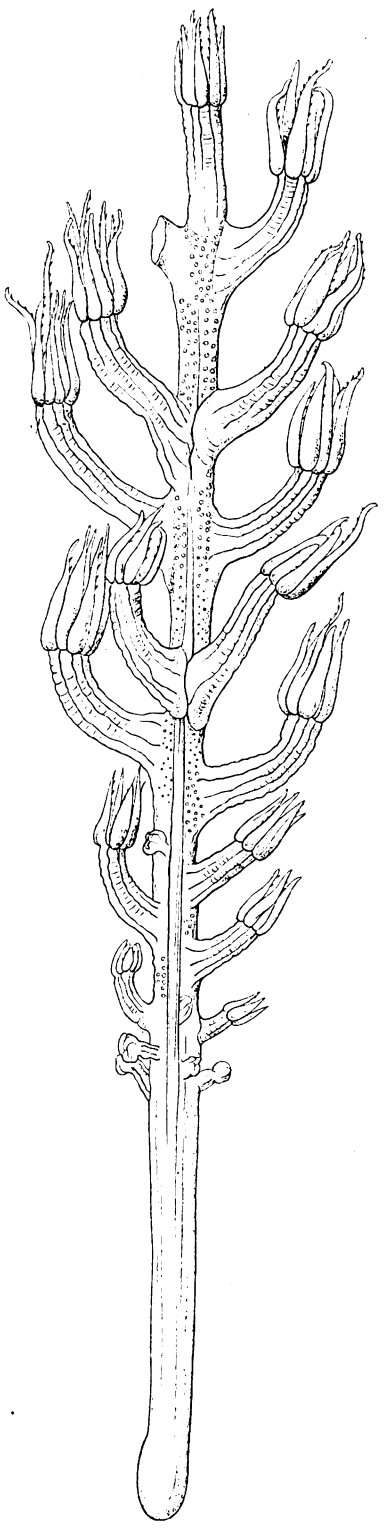

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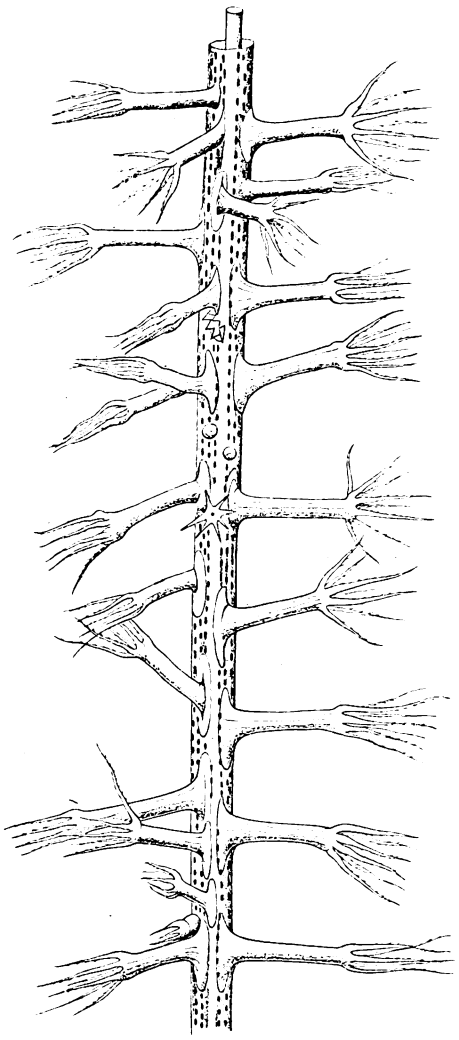

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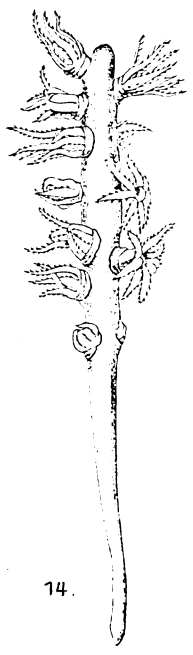

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PLATE III.

Fig. 15. *Chunella gracillima* Kükenthal. Specimen from Station 18, off Bali. 1018 metres. A part of the stalk is omitted where the gap is shown in the drawing. In other respects it is natural size.

Fig. 16. *Pennatula Murrayi* Kölliker. Station 289. N° 6. About $^2/_3$ natural size.

Fig. 17. *Gyrophyllum sibogae* n. sp. About $^2/_3$ natural size.

Fig. 18. *Echinoptilum roseum* n. sp. Dorsal view of the base of the rachis. Considerably enlarged.

Fig. 19. *Protoptilum celebense* n. sp. A part of the rachis of a specimen from Station 87, seen from the dorsal side. × 4 diam.

Fig. 20. The first and second regions of the rachis of *Umbellula antarctica* (2nd specimen). Natural size. Colour of spirit specimen shown.

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PLATE IV.

Fig. 21. *Echinoptilum minimum* n. sp. Dorsal view of the largest colony. × 2 diam.

Fig. 22. *Echinoptilum minimum* n. sp. Dorsal view of a medium sized colony. × 2 diam.

Fig. 23. *Echinoptilum asperum* n. sp. Ventral view of one of the colonies. × 2 diam.

Fig. 24. The upper part of *Umbellula Weberi* showing the spiral twist in the second region of the rachis. × 2 diam.

Fig. 25. *Umbellula pellucida* specimen B. × 3 diam. View of the second region of the rachis showing the siphonozooids and the large eggs in the anthosteles of the autozooids as seen through the thin transparent skin.

Fig. 26. *Umbellula pellucida* specimen B. × 3 diam. Showing the arrangement of the autozooids on the first region of the rachis.

Fig. 27. *Echinoptilum minimum*. Vertical section through one of the passages connecting an autozooid cavity with the lacunar system of solenia. *End.* Endoderm cells guarding the passage with darkly staining nuclei and probably ciliated. *msg.* mesogloea. × 200 diam.

Fig. 28. *Echinoptilum elongatum*. Vertical section through the lateral longitudinal canals (*l. l. c.*) and a part of the dorsal longitudinal (*d. l. c.*) and ventral longitudinal canals (*v. l. c.*) of the rachis showing the septa and one of the communicating passages (*p*). × 100 diam.

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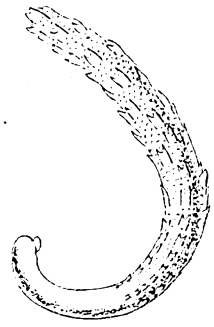

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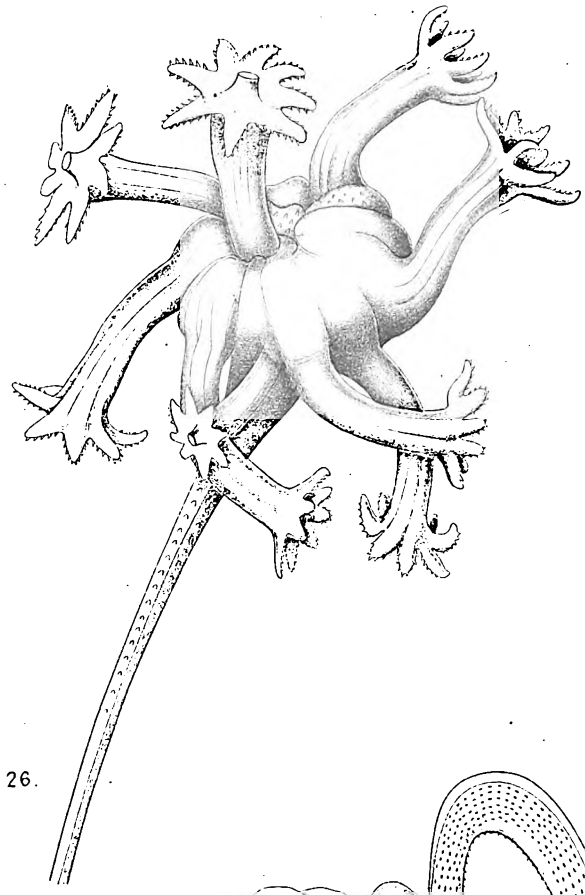

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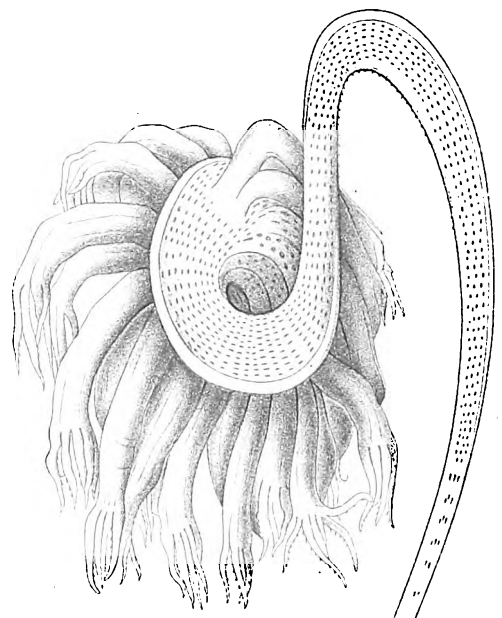

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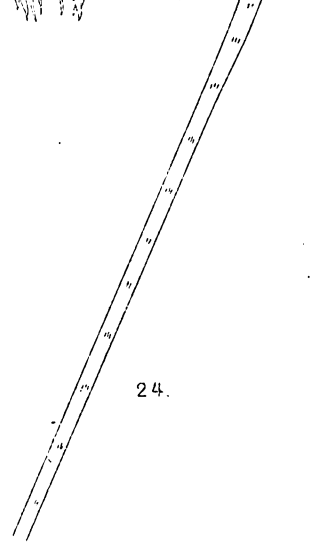

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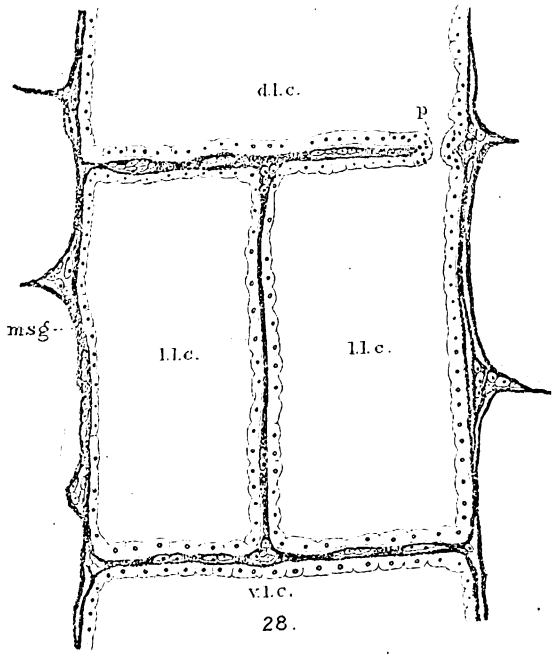

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PLATE V.

Fig. 29. *Echinoptilum roseum* n. sp. Ventral view of the ventral side of the only specimen in the collection. Natural size.

Fig. 30. *Echinoptilum elongatum* n. sp. Ventral view of the largest colony. × 2 diam.

Fig. 31, 32. Genus *Echinoptilum*. These two semidiagrammatic drawings represent transverse sections through the rachis of *Echinoptilum elongatum* (fig. 31) and *E. minimum* (fig. 32) respectively. In the former the sarcosoma (*sa.*) is a good deal thicker than it is in the latter. The walls separating the longitudinal canals and the autozooid cavities are also thicker. The number of siphonozooids is greater in *E. minimum* than in *E. elongatum*. The actual specimen of *E. elongatum* was a male and test sacks are seen in most of the autozooid cavities. The specimen of *E. minimum* was a female and ova are seen in most of the autozooid cavities. × 2 diam.

Aut. Autozooids with anthocodiae retracted. *Aut. 2.* Autozooids cavities cut across in a plane below the anthocodiae. *Si.* Siphonozooids in long. section. *v.* ventral canal of rachis. *d.* dorsal canals of rachis. *ll.* lateral canals of rachis. *m.m.* principal longitudinal muscles of rachis. *Sa.* sarcosoma. *ov.* ovary. *t.* testes.

Fig. 33. *Pteroeides malayense* n. sp. Station 79. N^0 2. Natural size. Dorsal side. At (*A*) may be seen the abnormal condition of two isolated autozooids detached from the leaf.

Fig. 34. *Pteroeides malayense* n. sp. Station 79^a. N^0 3. A part of the rachis and stalk showing a series of rudimentary stipules at the base of most of the leaves. Each of the stipules bears two or three spines and siphonozooids on the under side. Stipules are not usually present in this species.

Fig. 35. *Pteroeides timorense* n. sp. Dorsal view. Natural size.

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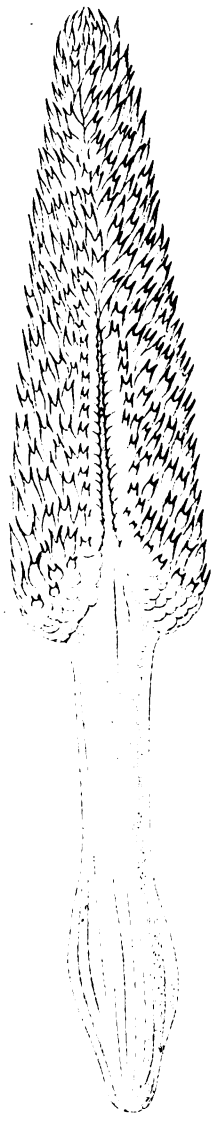

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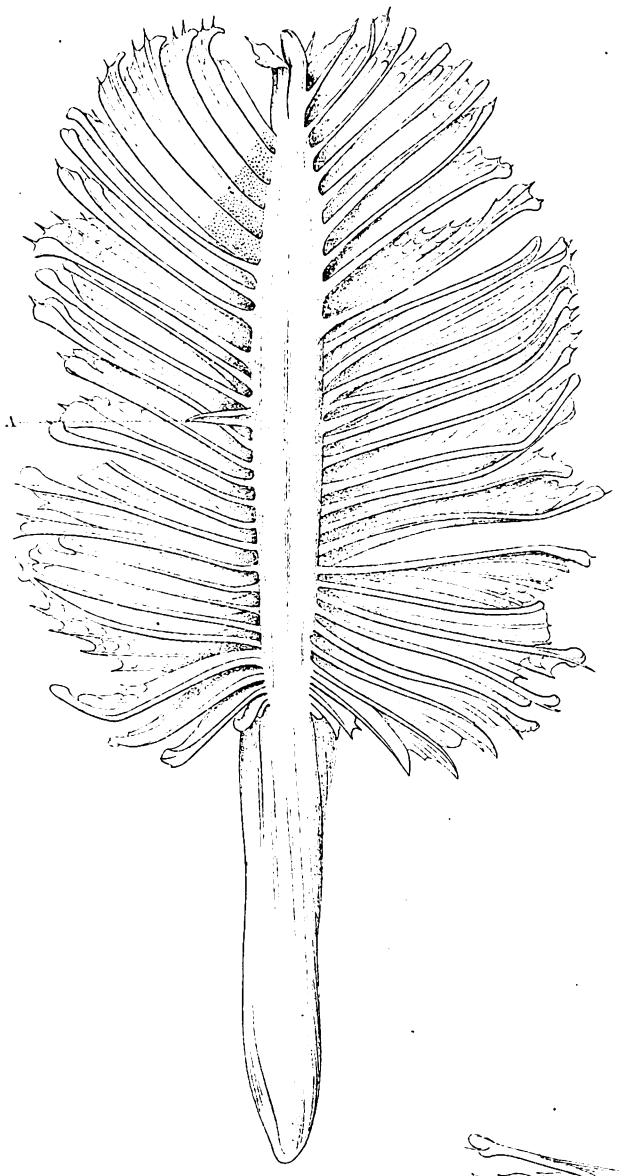

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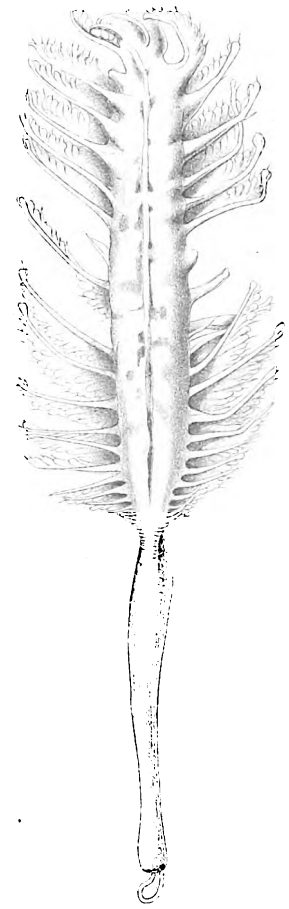

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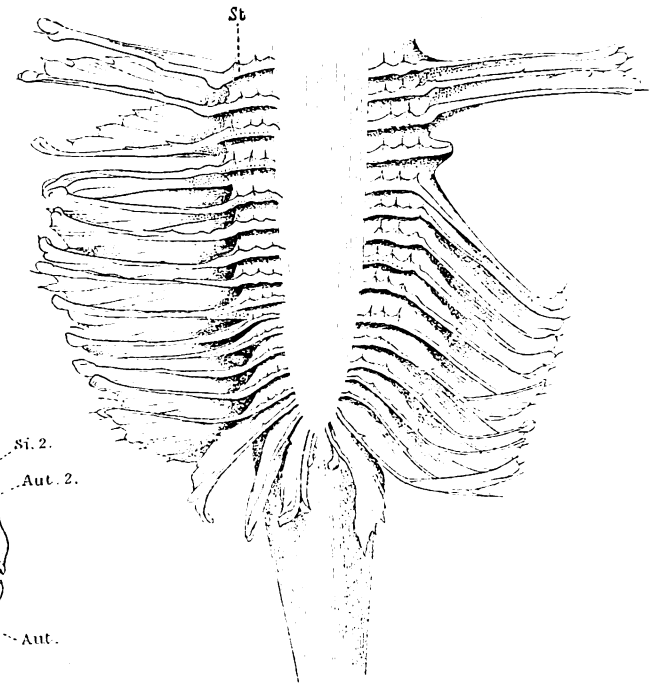

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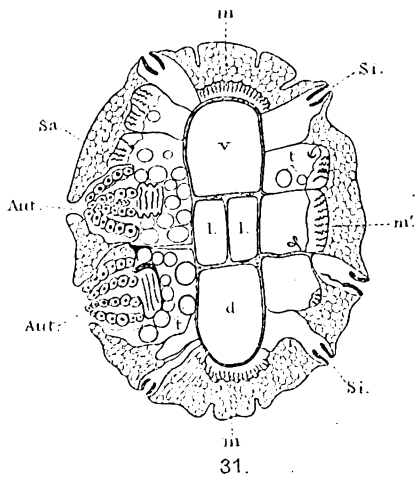

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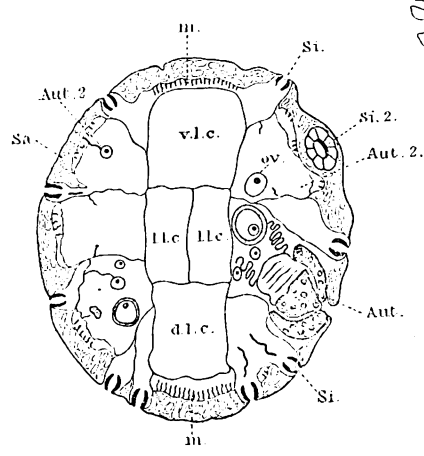

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PLATE VI.

Fig. 36. *Protoptilum celebense* n. sp. A young specimen from Station 212. × 6 diam.
Fig. 37. *Scytalium Martensii* Köll. A part of the lower end of the rachis and the beginning of the stalk showing the general proportions of the colony. × 2 diam.
Fig. 38. *Scytalium Martensii* Köll. A portion of the rachis of a specimen with the anthocodiae retracted. In some cases the dorsal autozooid of a leaf shows a digitiform process (*d. p.*). The single row of siphonozooids are shown (*Si.*). Dorsal view. × 4 diam.
Fig. 39. *Scytalium Martensii* Köll. Another specimen showing at "gon" the position of the gonads. Ventral view. × 8 diam.
Fig. 40. *Scytalium Balssii* n. sp. Ventral view. Natural size.
Fig. 41. *Scytalium Balssii* n. sp. Dorsal view. Natural size.

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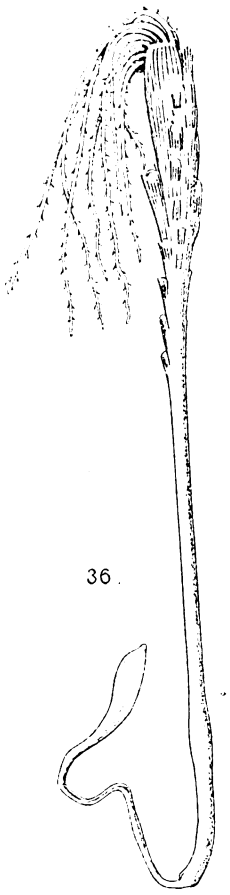

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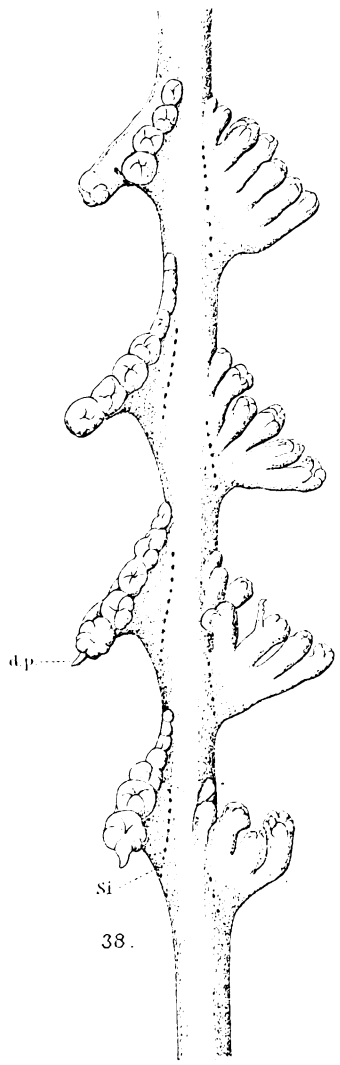

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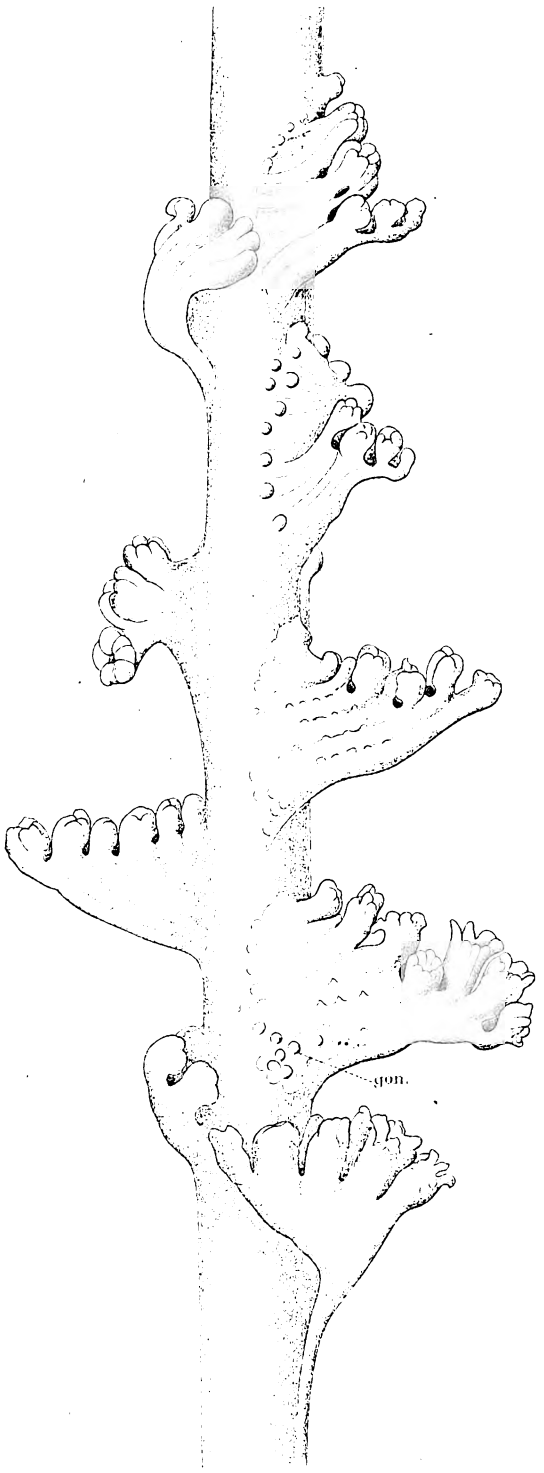

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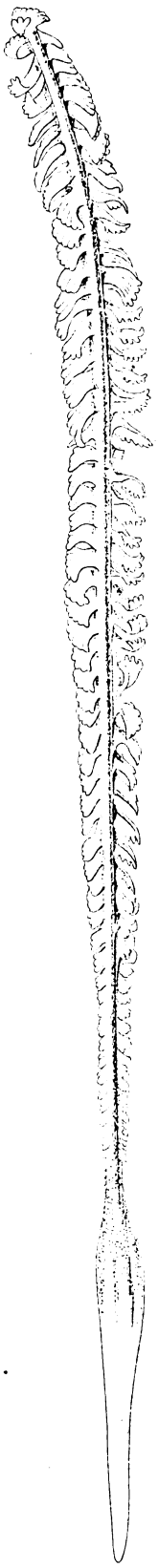

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PLATE VII.

Fig. 42. *Anthoptilum malayense* n. sp. A portion of the rachis seen from the dorsal side, showing the dorsal track (*D. t.*) and the band of siphonozooids on each side of it. Natural size.

Fig. 43. *Anthoptilum malayense* n. sp. The drawing shows the way in which the band of siphonozooids on each side of the dorsal track is interrupted opposite the edge of each alternate leaf. The letter "x" indicates one of these interruptions. Reduced to $^2/_3$ nat. size.

Fig. 44. Ventral view of a part of the rachis of *Virgularia Roulei* showing at *Si.* the position and arrangement of the siphonozooids.

Fig. 45. Dorsal view of the same.

Fig. 46. *Virgularia rubra* n. sp. A single leaf of a specimen from Amboyna. × 25 diam.

Fig. 47. *Virgularia rubra* n. sp. A single leaf from a specimen from Banda. × 25 diam.

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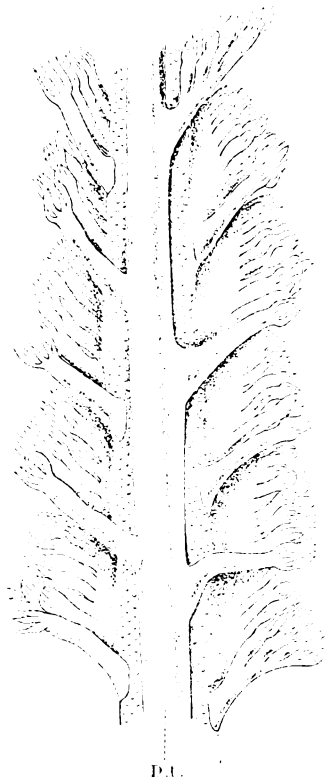

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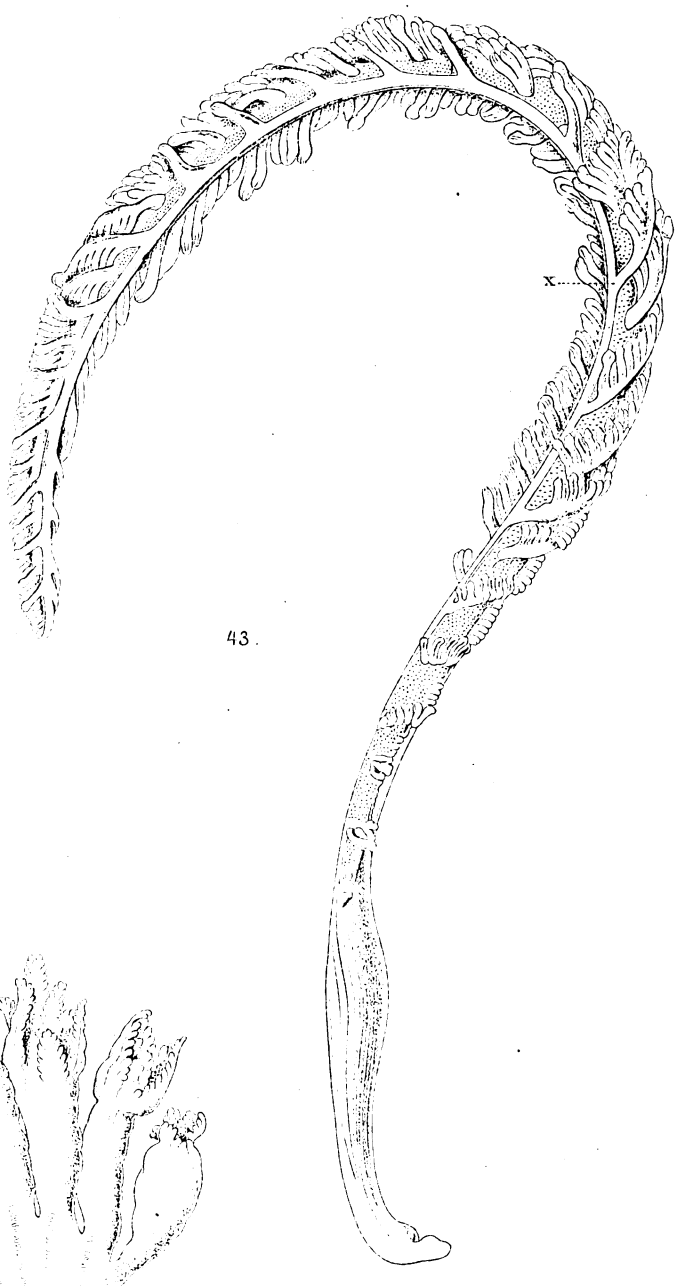

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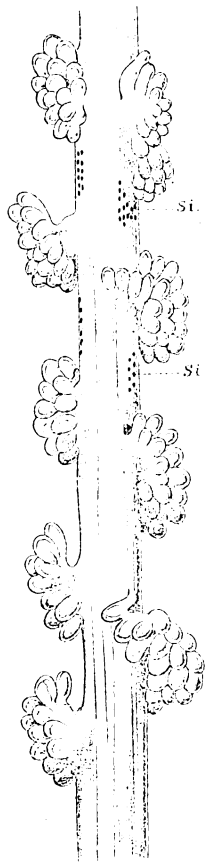

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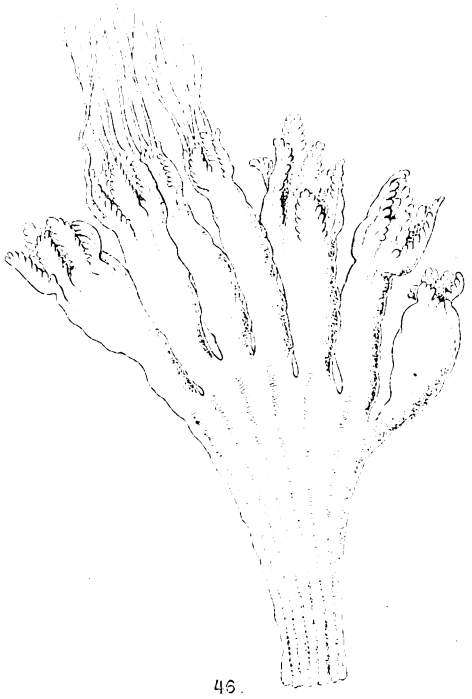

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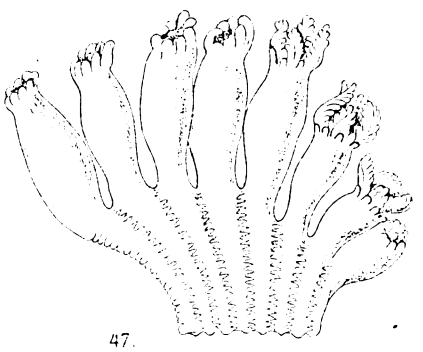

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PLATE VIII.

Fig. 48. *Gyrophyllum sibogae*. A portion of a leaf showing the two calyx teeth of the autozooids and the siphonozooids scattered over the surface of the leaf. × $2^1/_2$ diam.

Fig. 49. *Pteroeides timorense*. New species. A leaf showing the strong dorsal ray. *D. R.* × 3.

Fig. 50. *Pteroeides argenteum*. A leaf seen from the under side. × 3.

Fig. 51. *Pteroeides argenteum*. A part of a leaf showing two rays more highly magnified.

Fig. 52. *Pteroeides speciosum*. A leaf showing the strong dorsal ray *D. R.* × 3.

Fig. 53. *Pteroeides malayense*. A single leaf showing the basal siphonozooid plate (*S.P.*). About $^2/_3$ Nat. size.

Fig. 54. *Pteroeides caledonicum*. A single leaf showing a median siphonozooid plate (*S.P.*). About $^2/_3$ Nat. size.

Fig. 55. *Scytalium Balssii* n. sp. A portion of one of the leaves to show the digitiform processes on the calyx of the autozooids.

Fig. 56. *Scytalium Balssii* n. sp. One of the calices enlarged.

Fig. 57. *Pteroeides malayense*. Transverse section of a mesozooid surrounded by a lacunar system of solenia (*so.*) showing muscle bands on both sides of the lateral mesenteries *l. m.* and the small imperfectly differentiated siphonoglyph (*si.*) in the wide stomodaeum (*St.*). × 50 diam.

Fig. 58. Vertical section through a part of the dorsal track of *Anthoptilum*. *Ep*. Superficial epithelium (the numerous gland cells present in this epithelium are not represented). *D. l. c.* main dorsal longitudinal canal. *M.* Muscular layer between the epithelium and the radial canals. *mf.* mesenteric filament in section. *So.* Solenia. *R. c.* radial canals. *Si.* siphonozooids.
The sections were made from a specimen of *Anthoptilum grandiflorum* from the Cape of Good Hope.

Fig. 59. Vertical section through a part of the dorsal track of *Virgularia Rumphii*. *Ep*. the superficial epithelium consisting of columnar cells with scattered gland cells. *So.* the solenia or nutritive canals lined by irregular endoderm cells with a. few zoochlorellae (*z.*). *Rc.* the radial canals lined by a columnar epithelium. At *Rc'* is shown a canal with numerous thread like bodies in the lumen which are interpreted to be the detached cilia of the canal epithelium.

Fig. 60. Vertical section through the very immature leaves at the base of the rachis "zooidstreifen" of *Virgularia Rumphii*. There are five young autozooids represented, *A1* is the oldest on the dorsal side, *A5* the youngest on the ventral side. In the cavities of the autozooids are seen some young ova, *O*. *Ep*. the surface epithelium with gland cells. *M.* the muscle bands.

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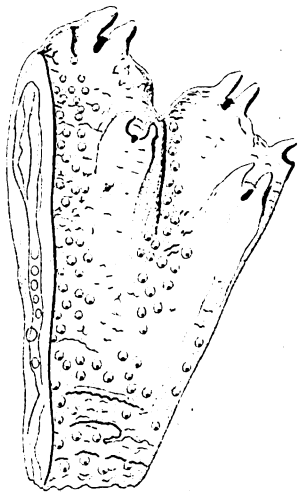

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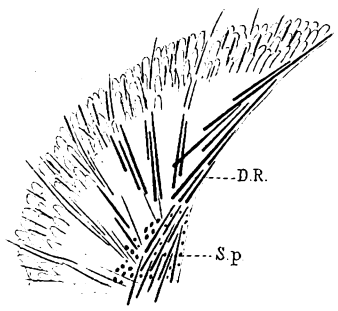

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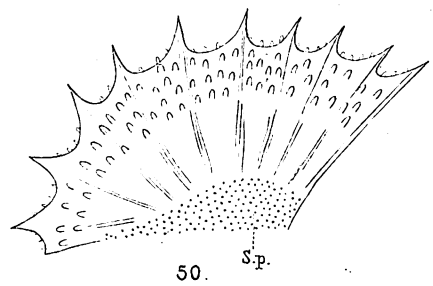

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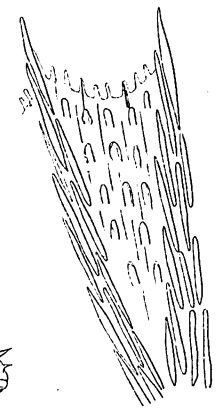

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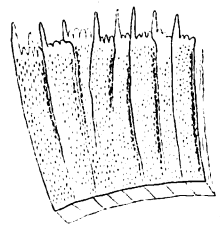

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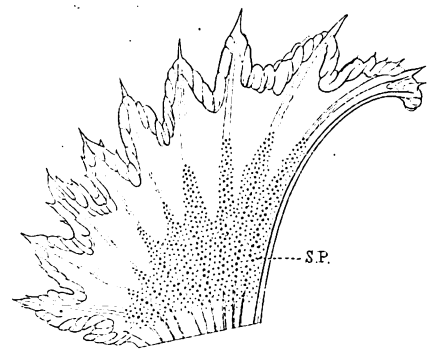

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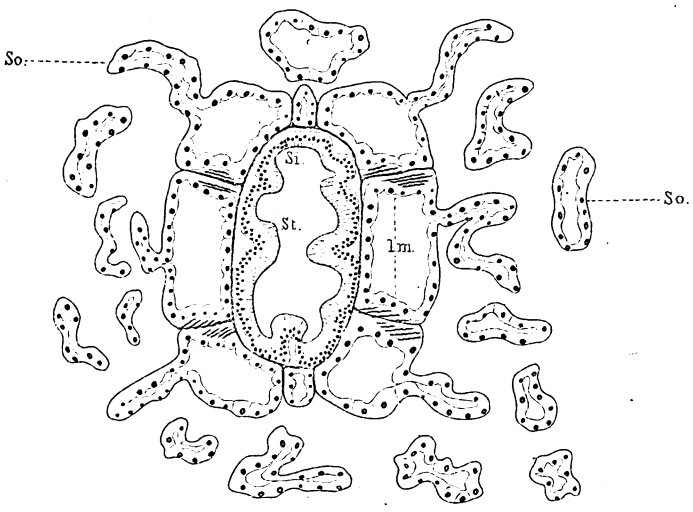

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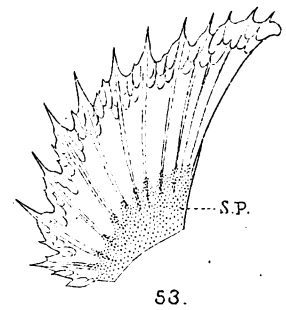

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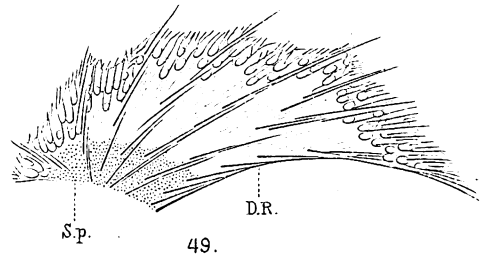

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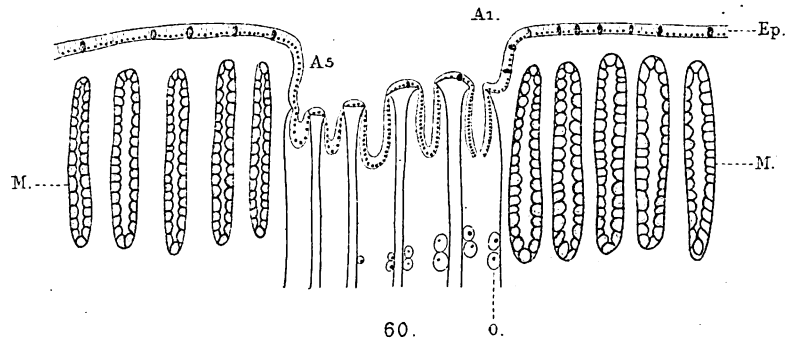

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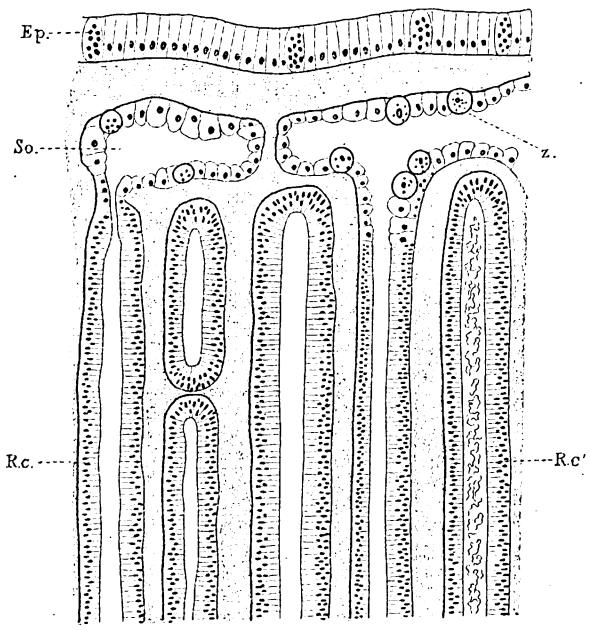

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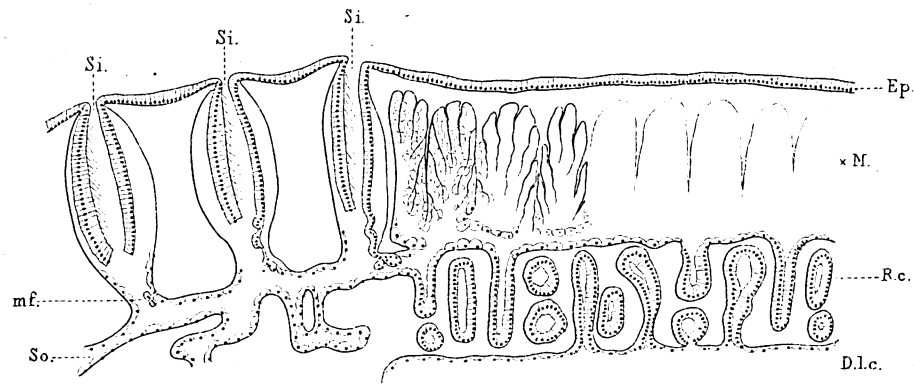

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PLATE IX.

Fig. 61. Surface view of the axis of *Virgularia gracillima* showing the striated ridges.

Fig. 62. Surface view of the axis of *Virgularia Rumphii* showing the striated ridges.

Fig. 63. Surface view of the axis of *Virgularia juncea* showing rough tuberculated ridges.

Fig. 64. Spicules and groups of spicules from basal bulb of *Virgularia gracillima*. × 400 diam.

Fig. 65. *Pennatula Murrayi*. Transverse section through the rachis to show the relation of the Mesozooid (*Mes.*) to the lateral longitudinal canals and to a brown tube (*B.t.*) × 21 diam. *Aut.* Autozooids of the leaves. *Ax.* Axis. Brown tube *B.t.*. *d.l.c.* Dorsal longitudinal canal. *l.l.c.* Lateral longitudinal canal. *M.d.*, *M.v.* Dorsal and ventral muscle bands of the rachis with spongy tissue. *Mes.* Mesozooid communicating directly with the left lateral longitudinal canal. *Ov.* Ova in the cavities of the autozooids. *Si.* Siphonozooid. *v.l.c.* Ventral longitudinal canal.

Fig. 66. *Pennatula Murrayi*. Drawing of the base of two leaves showing the position of the mesozooids and siphonozooids on the dorsal track. Considerably enlarged.

Fig. 67. *Pennatula Murrayi*. Horizontal section of the dorsal track taken between the base of a leaf (*L.*) and the mid-dorsal line (*xx*) showing a mesozooid (*Mes.*) and several siphonozooids in transverse section. The position of the brown tubes is also shown *b.t.* The muscles on the mesenteries of the mesozooid are described in the text, p. 195. × about 100 diam.

Fig. 68. *Pennatula Murrayi*. Longitudinal vertical section of the dorsal track showing the whole course of two of the brown tubes *b.t.* with their funnel shaped openings into the lateral long. canal *l.l.c.* *Ep.* Surface epithelium. *So.* Solenia. *Spic.* spicule spaces. *m.* Dorsal muscle bands. *l.l.c.* Lateral longitudinal canal.

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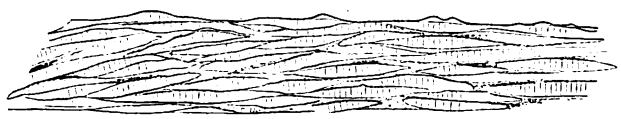

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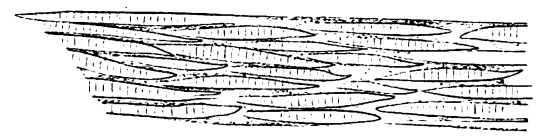

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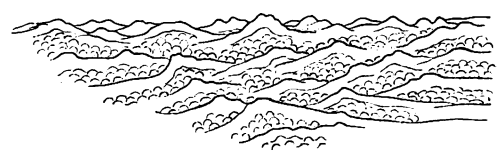

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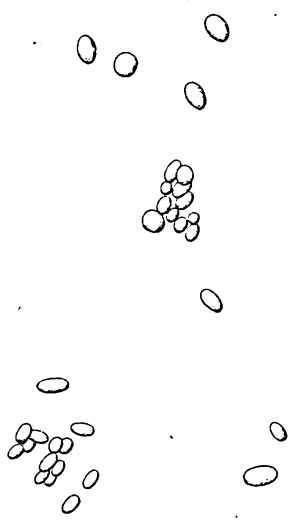

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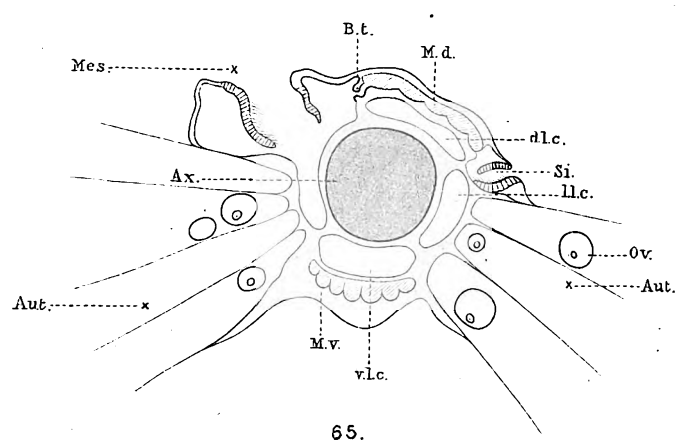

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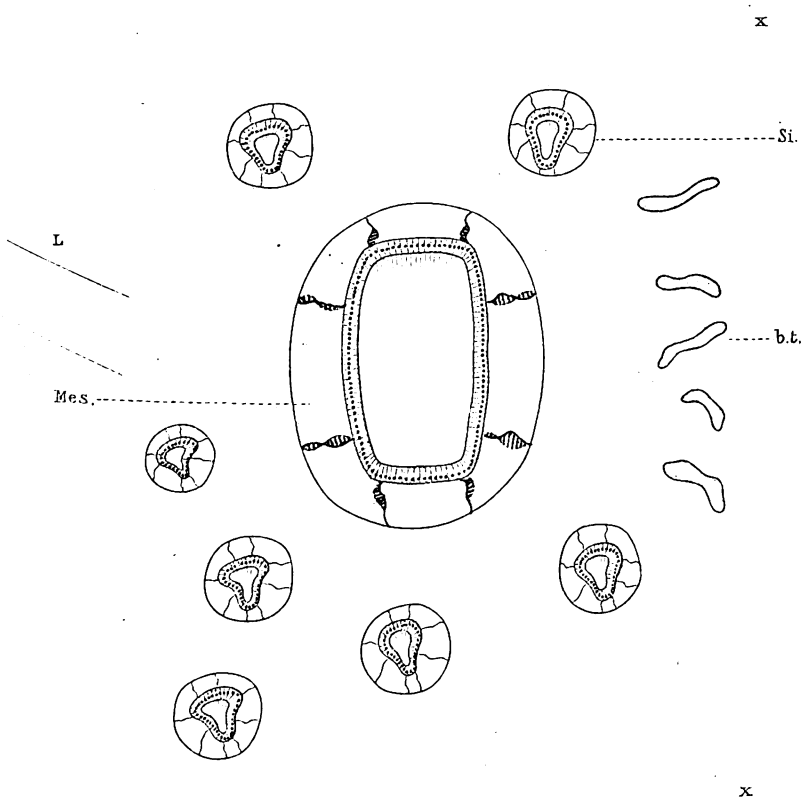

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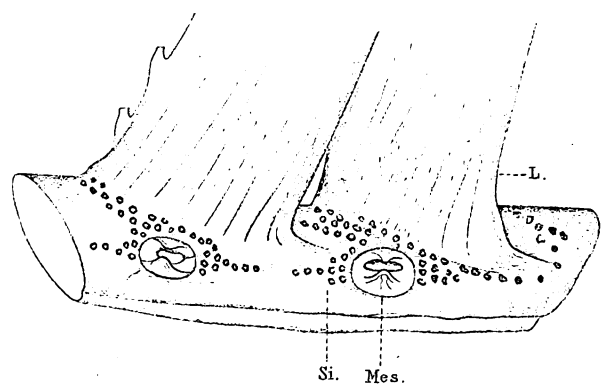

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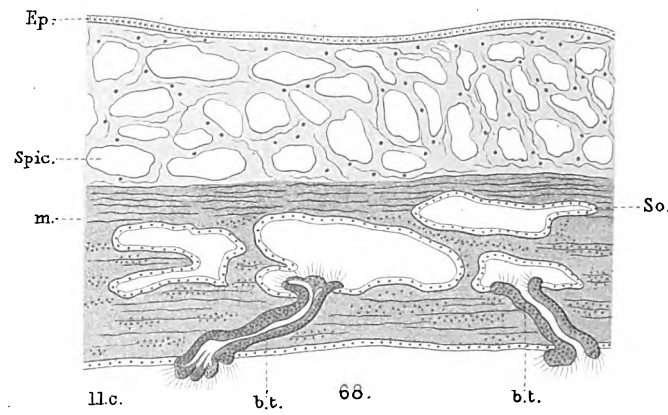

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PLATE X.

Fig. 69. *Pteroeides speciosum*. Young. Ventral. × 1 1/2 diam.
Fig. 70. *Pteroeides speciosum*. Young. Dorsal. × 1 1/2 diam.
Fig. 71. *Pteroeides caledonicum*. Young. Dorsal. × 2 diam.
Fig. 72. *Pteroeides caledonicum*. Young. Ventral. × 2 diam.
Fig. 73. *Pteroeides sagamiense*. Young. Dorsal. × 2 diam.
Fig. 74. *Pteroeides chinense*. Young. Ventral. × 2 diam.
Fig. 75. *Pteroeides chinense*. Young. Dorsal. × 2 diam.
Fig. 76. Leaf of *Pteroeides nigrum*. × 9 diam.
Fig. 77. *Umbellula durissima*. Spicules. × 5.3 diam.
Fig. 78. *Pteroeides malayense*. Series of spicules. × 11/14 diam.

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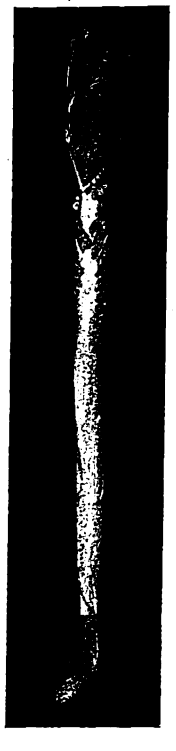

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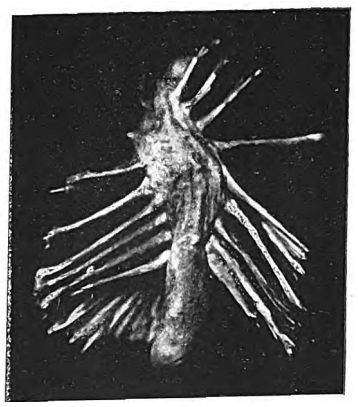

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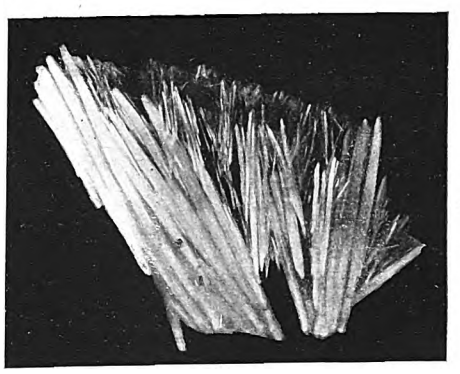

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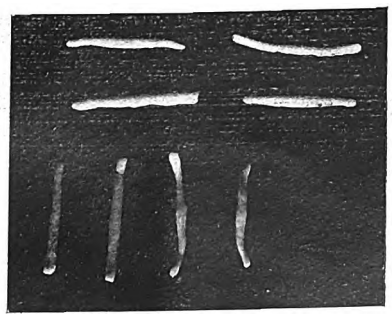

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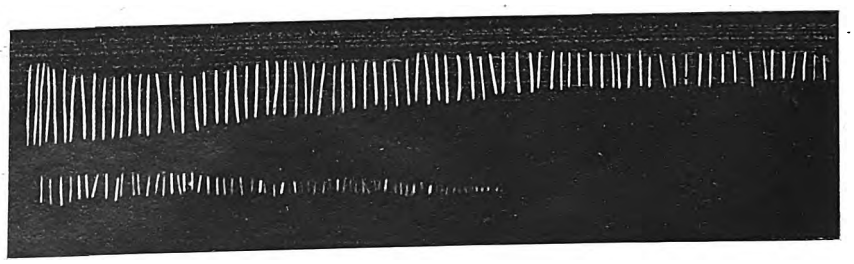

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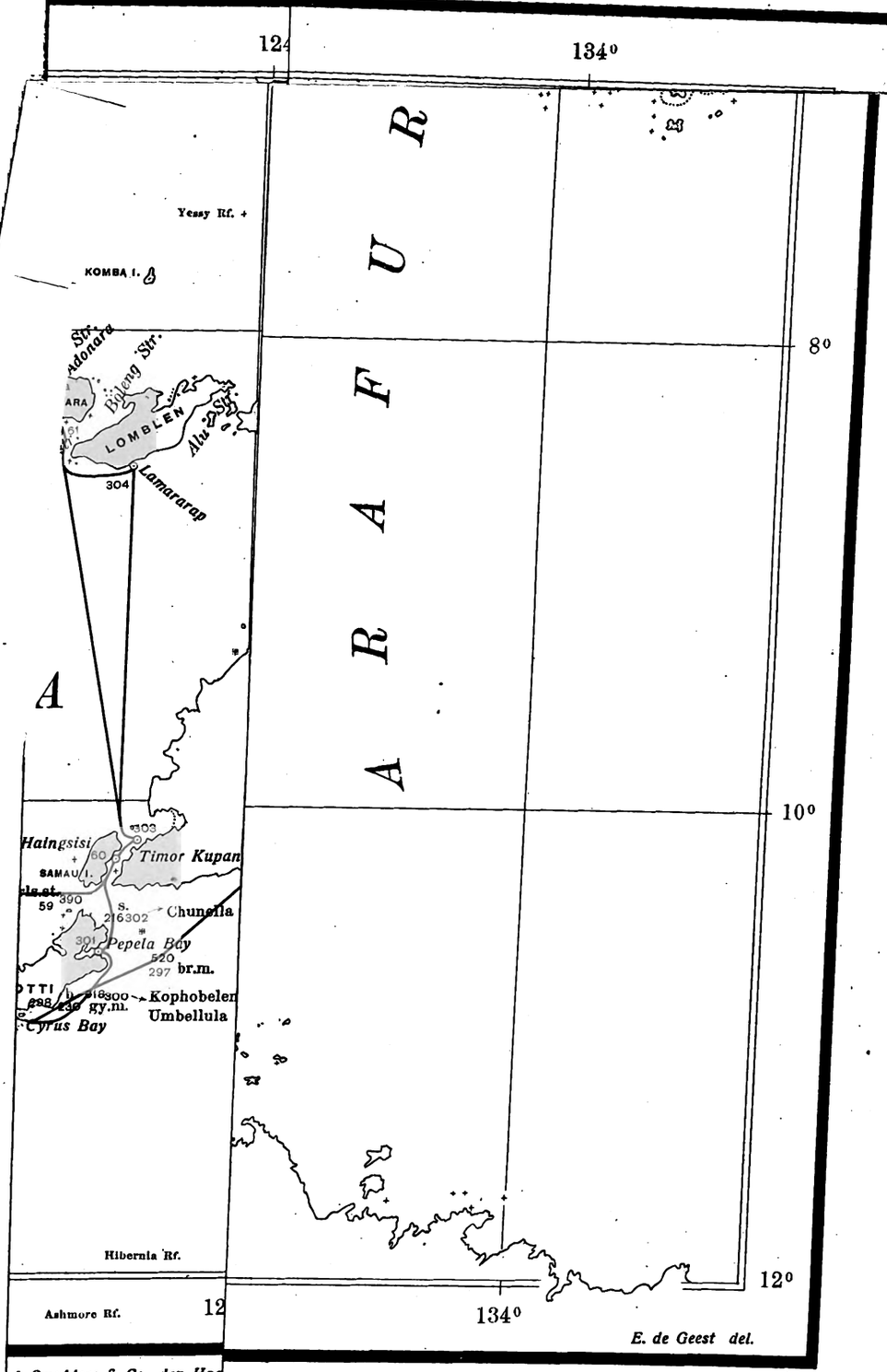

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